The Illinois

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JANUARY 1973, NO. 123

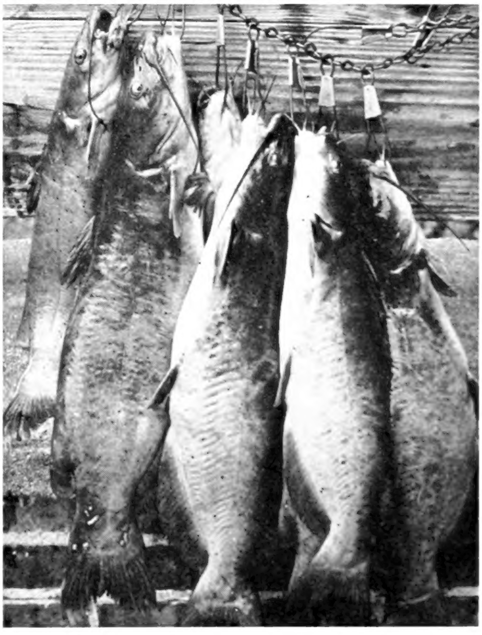
Hot Angling Spot — Ridge Lake

This summer, under a system of feeding and with fall drawdowns every third year, aquatic biologists George W. Bennett and H. Wickliffe Adkins obtained the largest fish yield ever recorded from Ridge Lake (sixteen acres) in Fox Ridge State Park near Charleston. The lake contains largemouth bass, bluegills, warmouths, channel catfish, and lake chubsuckers. A summer feeding program consists of spreading prepared fish pellets (32 percent protein) in the shallows around the edges of the lake at the rate of two pounds per acre per day (thirty-two pounds per day at a cost of about ten cents per pound). This fall after summer fishing was over the lake level was lowered nine feet (maximum depth twenty-five feet at the outlet) to pull the water from the beds of aquatic vegetation and cause a reduction in the number of small bluegills.

The catch of fish from controlled public fishing, which began in early June and ended the last of August, totaled 139.6 pounds per acre with 338 man-hours of fishing per acre. Nearly half of the catch was composed of channel catfish which averaged two and a half pounds each. These catfish represented 442 of 691 returned to the lake in 1970 after the spring draining and fish census. They originated from catfish farming stocks obtained from Arkansas and propagated at our Sam A. Parr Cooperative Fisheries Research Center at Marion County. Channel catfish do not reproduce successfully at Ridge Lake, and replacement stock must be added as these fish are taken.

Catfish grow very rapidly in this lake under the supplemental feeding program. The largest fish taken in 1972 weighed a few ounces over ten pounds. We plan to stock about 1,000 to 2,000 catfish per year to maintain the high level of catch return. With a 14-inch minimum limit, the small catfish have a chance to reach useful sizes before being taken by fishermen.

Bluegills were next in importance in the 1972 catch, and 5,745 fishes weighing 914 pounds were taken. This catch amounted to 359, weighing 57 pounds per acre. Because the catch of bluegills of less than six inches total length exceeded those of more than six inches (3,100 to 2,600), it was



Channel catfish caught in Ridge Lake. (Photograph by George W. Bennett)

decided that it was time to make a fall drawdown. This was done beginning August 29, when in a period of seventy-two hours the lake was gradually lowered nine and a half feet. The drawdown reduced the surface area to 69 percent of the full lake and the total volume of water more than 50 percent. Small fishes were forced out of aquatic vegetation and shoreline debris into open water where the larger fishes could prey upon them.

During late May and early June an unusual source of food became available to the fishes of Ridge Lake. A heavy emergence of 1972, Brood XIX, 13-year cicadas occurred in Fox Ridge State Park and around the lake. Cicadas falling into the water were immediately eaten by fishes. Counts of these downed insects in measured strips of lake shallows gave basic figures for an estimate of the total number falling into the lake per day, and the cicadas were abundant over a 21-day period. As the average weight of these insects was approximately 0.6 gram, the weight of insects falling into the lake was estimated to be 363 pounds per day or 3.8 tons for the 21-day period. This food source probably added materially to the fish production of the lake.

Wood Ducks — Tagged and Bagged

Wood duck ducklings were marked with metal tags attached to their toes during the nesting season in 1971 and again in 1972. Most of the ducklings were marked when less than twenty-four hours old while they were still in nest houses. However, in 1971 about 60 marked ducklings were from broods deserted by their mothers in Havana. These ducklings were tagged and released in Quiver Creek. In 1971 a total of 613 wood duck ducklings were marked, about half of which were males. This tagging program was carried out by wildlife biologist Robert Crompton.

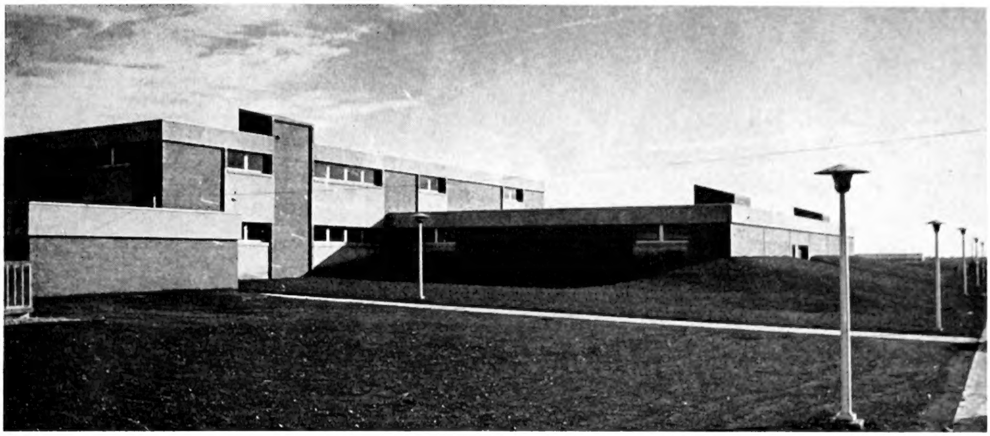
Out of about 300 female ducklings tagged in 1971, 38 were captured in 1972. Of these, 35 were found nesting in wood duck houses and 3 others were captured in banding traps after the nesting season. Biologist Frank C. Bellrose feels that the 3 ducks found in banding traps had nested in natural cavities rather than the nesting houses provided for wood ducks in the area. No web-tagged males were captured, but one male banded while flightless in 1971 was recaptured in 1972. From these and other data, Bellrose concludes that yearling females home to their natal area to a much greater extent than do male wood ducks.

Surprisingly, five of the returning birds were from the sixty orphaned ducklings picked up in Havana and released in Quiver Creek. Their survival rate was comparable to that of ducklings with mothers. Either the orphaned ducklings had unusual ability to survive without parental brooding and guidance, or more probably, they were readily adopted by hens with broods.

Yearly differences in the rate of homing by wood ducks will provide information on differences in their survival resulting from changing habitat conditions. For example, during the summer of 1971, brood habitat was poor for wood ducks due to unusually low water levels. In 1972, however, brood habitat was excellent because of high water levels. Robert Crompton web-tagged 969 ducklings during the 1972 nesting season in order to compare differences in the survival of wood duck ducklings with changing habitat conditions. Nowhere in the country have as many ducklings been marked as on our Quiver Creek study area during the past two years.

Environmental Research Facility Completed

After months of frustrating delays, the new Natural Resource Studies Annex, located at the intersection of Griffith and Hazelwood drives on the Urbana-Champaign campus of the University of Illinois, was declared "essentially completed" on December 8, 1972. Designed specifically for greatly accelerated research on problems of environmental quality, the Natural History Survey portion of the new building includes several dozen laboratories and offices plus a greenhouse containing some sixteen cubicles which can be individually programmed for specific light and temperature regimes. The State Geological Survey occupies lesser



Natural Resource Studies Annex. (Photograph by Survey photographer Wilmer Zehr)

laboratory and office space plus a large storage area for its library of drill cores.

About half of the new laboratory and office equipment required for the structure is now installed and operative. It is hoped the remainder can be obtained this year. A portion of the Survey's existing staff has moved to the new laboratories. Additional talents not represented in depth among the present staff are expected to be employed within the next six months. When fully equipped and staffed, the Natural Resource Studies Annex, augmented by the existing facilities and staffs of the Natural History Survey and the Geological Survey and our nearby Aquatic Research Field Facility, will constitute one of the finest analytical research activities in the nation.

The Natural History Survey has long been engaged in studies of environmental quality — particularly those which involve pesticides and heavy metals. The capabilities afforded by the new facility will permit the Survey to place increased emphasis on investigations designed to produce a more penetrating understanding of environmental contamination. These areas of study will include: the behavior and fate of pesticides in the soil and water environments and the degradation mechanisms involved; the specific primary and secondary biological effects of various levels of soil and waterborne pesticide residues in animals and plants; the biological response of animals and plants to atmospheric pollutants; and the impact of contaminants on plant and animal community structure. Thus, we hope to find more meaningful and precise answers to a variety of questions related to the kinds and amounts of environmental contamination man and his animal and plant colleagues can or will tolerate in the tradeoffs for the sustained production of products and services that contribute to the standard of living which we strive to maintain.

Crop Pests of 1972

The twenty-fifth annual Custom Spray Operators Training School will be held January 23-25, 1973, in Urbana. During this session a report will be presented dealing with insect pests and their control in Illinois during the previous year. This report, prepared by Survey entomologists Roscoe Randall and Donald E. Kuhlman, is a summary of data received from county extension advisers in agriculture and includes comments on major problems of the past year and an outlook for the coming season.

Each year is different in terms of insect activity. Insect problems, although varied, did not present any major incidents in 1972. Black cutworms, armyworms, and alfalfa weevils were the most troublesome agricultural pests, especially in the southern half of the state. The major nonagricultural insect problems in Illinois involved mosquitoes, periodical cicadas, and sod

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webworms. For several years Illinois has not had any catastrophic outbreak of pests as occurred years ago before the advent of modern insecticides.

Western corn rootworm beetles were found for the first time in Douglas, Greene, Macoupin, Montgomery, Moultrie, Piatt, Schuyler, Scott, and Vermilion counties in 1972. This pest has now been found in sixty-three counties in Illinois since first discovered in the state in 1964. The areas with the greatest potential for corn rootworm damage in 1973 will be in western, northwestern, and central sections of Illinois. In general, fields in continuous corn production for three years or more in the area north of a line from Pittsfield to Springfield and Joliet may incur moderate to severe damage by corn rootworms. This area may also expect damage to second-year corn by the western corn rootworm.

A wet, cool spring favored armyworm populations this spring, and the southwestern and southeastern areas of Illinois were plagued by large numbers of armyworms. This insect is a southern migrant into Illinois and presents problems in some areas every year. The moths generally select thick, dense stands of grass in which to deposit their eggs, and it is impossible to accurately predict infestations more than a few weeks in advance.

Many fields of corn in the southern half of Illinois were damaged by black cutworms during the past year. Damage in northern Illinois was less widespread. Excellent control of this insect was obtained by most farmers by using carbaryl (Sevin)-apple pomace bait, carbaryl-molasses, or carbaryl-Tractum spray. The few instances of poor control were due to extremely wet or extremely dry weather. In the first instance the bait was broken down rapidly and rendered ineffective by heavy rain. In the second case the cutworms fed below the soil surface to avoid heat and were not attracted to the bait on the surface.

An estimated 6,769,000 acres of Illinois field crops were treated with insecticides in 1972, resulting in a savings from crop losses (above treatment costs) to farmers of about $23,800,000. The control of soil insects in corn accounted for 90 percent of these savings. It is clear that insecticides are necessary for the profitable production of certain field crops in Illinois.

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FEBRUARY 1973, NO. 124

Quail Abundance Not Reduced by Hunting

The bobwhite quail is a very popular upland game bird in southern Illinois. On state-owned conservation areas in the southern part of the state where quail are abundant, bobwhites provide the bulk of game bird hunting. Since two of these areas are managed and hunting is regulated by the Illinois Department of Conservation in cooperation with the Illinois Natural History Survey, it has been possible for Survey scientists to study the effect of hunting pressure on quail populations.

The study areas are Stephen A. Forbes State Park (2,300 acres) in Marion County and Sam Dale Lake Conservation area (1,300 acres) in Wayne County. Hunting regulations on the areas are identical with state regulations except for hunting hours and a compulsory game checking procedure. During the period of the study reported here, hunting hours were from 8:00 a.m. to 4:00 p.m. daily from mid-November to December 31, with a daily limit of eight birds. Hunters are required to check in at the ranger station before and after hunting and declare all game taken.

Quail censuses are conducted three times each year: a postharvest census in late January, a prebreeding census in March, and a prehunt census in November. Results of census and harvest data for 1964-70 were recently summarized by Survey wildlife specialists D. R. Vance and J. A. Ellis with the following conclusions:

Bobwhite populations on the Forbes and Dale areas have been intensively utilized by hunters since 1964, with an average of 60-70 percent, and as high as 81 percent, of

Young bobwhite quail. (Photo by Survey photographer Wilmer Zehr.)

fall quail populations being harvested with no apparent detrimental effects on subsequent population levels. Although other workers have suggested a safe harvest limit of 45 to 50 percent of prehunt quail populations, Vance and Ellis feel that, under existing environmental conditions and hunting regulations in Illinois, the annual harvest of bobwhites on managed public hunting areas in Illinois may safely remove 70 percent of the quail population. They also concluded from these data that hunting interest is directly related to quail abundance; therefore, this high level of harvest will not occur in years of low quail abundance due to a lack of hunter interest. Merely providing the land and opening the season does not provide hunting opportunity. Hunting opportunity can be increased on existing public hunting areas by providing more game through effective habitat management.

Several facts disclosed by this study should be of interest to quail hunters and those contemplating taking up the sport. The "average" hunter on both the Dale and Forbes areas flushed about one covey per trip and killed one bird out of the covey. Hunting time required averaged about three hours per bird. The most successful hunters were residents of the six-county regions surrounding the areas, with hunters from the St. Louis and Chicago metropolitan areas only about half as successful. The highest hunting success occurred on weekdays during the first week of the season.

With these facts in mind, it looks like quail hunting is here to stay in Illinois but fellows, you've got to get out and work for 'em! Good luck, quail hunters!

Biochemical Markers in Corn Earworms

The corn earworm is one of the most destructive pests of American agriculture. Many millions of dollars in damage are caused by this pest each year and millions of pounds of pesticides are applied annually for its control. Although corn and cotton are the insect's preferred host plants, the earworm also attacks several other cultivated plant species. Because of its great economic importance, the earworm is a prime target for an insect management program.

Before an effective program can be instituted, a thorough knowledge of the insect's life history and habits must be at hand. One habit of the earworm that has been a great mystery to entomologists for many years is it migratory ability. The major portion of the earworm population probably cannot overwinter successfully in northern Illinois. Yet, once every two or three years during late August to early September, northern Illinois is invaded by very large numbers of earworm moths. It is strongly suspected that these moths have come to this area from somewhere outside of the state.

Although the earworm is considered to be one species of insect, many strains or perhaps subspecies exist in nature. These cannot be separated on the basis of visual characters. In recent years, increased emphasis is being placed on the use of biochemical techniques to separate or characterize insect populations. Survey entomologist D. K. Sell has recently developed a biochemical test which may prove highly useful in working with the earworm.

Insects, like all other organisms, differ genetically and Survey scientists have been searching for genetic markers of a biochemical nature in corn earworm larvae that can be easily monitored in populations of this insect. One such marker has now been found in the form of a genetic locus which controls the synthesis of an esterase present in the blood or hemolymph of corn earworm larvae. This locus was chosen as a model system and will be subject to further genetic and ecological analysis.

Since three pairs of genes are present at the locus, six different phenotypes of the insect are possible in any population. Once these types can be identified biochemically and separated, it should be possible to study certain key population parameters, including migratory ability, for each type. In this manner the source of the earworm infestation might be traced and certain key facts associated with this type would be known that would aid in selecting an effective pest management system.

Hybrid Vigor in Bass

Although people have realized for a long time that certain hybrids, the mule for example, grow to a larger size, are stronger, and are more resistant to diseases than their parent species, it has only been in recent years that some of the genetic causes of this phenomenon have been clarified. New biological techniques have recently been perfected which permit the genotypes of individuals to be determined. One such technique is electrophoresis.

Each species has characteristic proteins, and by electrophoretic methods, it is possible to identify the proteins of each species. Consequently, in a hybrid, proteins from both parental species can be identified. If a first generation hybrid (F_1) is backcrossed to one of its parents, the offspring will exhibit many different characteristics ranging from those of the parental species to those of the F_1 hybrid. However for a specific single genetic trait, half of the backcrossed individuals should be like the F_1 hybrid parent and the other half like the parent species that was used.

Survey aquatic biologists W. F. Childers and J. A. Tranquilli hybridized largemouth bass with smallmouth bass. They then backcrossed a male F_1 hybrid with a female largemouth bass. The reciprocal cross (female F_1 hybrid x male largemouth bass) was also made. The backcrossed hybrids were produced in separate ponds. Collections of approximately two hundred backcrossed hybrids were made from each pond when the young fish were about two months old. Each backcrossed hybrid was weighed, measured, and analyzed by electrophoresis. The electrophoretic analyses were conducted by Dr. Gregory Whitt and Mr. Thomas Wheat of the University of Illinois. Each individual was identified as being like the largemouth bass parents or the F_1 hybrid parent for three different proteins.

Backcrossed hybrids from the male F_1 x female largemouth bass showed great differences in rates of growth. Electrophoresis revealed that individuals which were genetically like the F_1 hybrid grew approximately twice as fast as those which were genetically like the largemouth bass parent.

Hybrid bass. Cross between male smallmouth and female largemouth. (Photo by Dr. G. W. Bennett.)

Offspring from the reciprocal cross (female F_1 hybrid x male largemouth bass) showed no appreciable differences in rates of growth.

Sperm contains almost nothing other than genetic material, and eggs contain genetic material and egg cytoplasm. The egg cytoplasm is utilized as food by the developing embryo. Consequently, the results of this experiment indicate that in these species hybrid vigor results when mixed genetic material from two species interacts with pure species egg cytoplasm but not when mixed genetic material interacts with mixed egg cytoplasm.

Environmental Inpact Info Sought

The Cooperative Wildlife Research Laboratory of Southern Illinois University at Carbondale, Illinois, is researching an Environmental Inpact Statement for the U.S. Army Corps of Engineers, concerning the effects of a Mississippi River channel-

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ization project. They are specifically interested in the area between the bluffs on each side of the river from St. Louis to Cairo, Illinois. The study encompasses a survey of the plants, mammals, amphibians, reptiles, birds, and nonaquatic invertebrates. Research will be completed by May 1, 1973.

One aspect of the project is to discuss with biologists and other biologically oriented citizens their observations of the flora and fauna, both unusual and common, in the floodplain. Since channelization of a waterway can drastically alter the ecosystems in the floodplain as well as in the river itself, it is essential to obtain as much information as possible on the plants and animals in the affected area before the project is approved. After channelization is approved and funded, it is too late to prevent undesirable environmental effects.

If any readers feel they could contribute some information about the plants or animals in the study area, please contact:

Mrs. Virginia A. Terpening
Assistant Investigator, River Project
Cooperative Wildlife Research Laboratory
Southern Illinois University
806½ South Marion
Carbondale, Illinois 62901

Time is running short. Your cooperation would be appreciated.

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The Shrike and Its Prey

So often in biological studies, what we perceive as the truth is strongly biased by the technique of observation we employ. Recently, in the course of summarizing the Illinois data on birds of the family Laniidae (shrikes), Richard and Jean Graber were impressed, both from the literature and their own field notes, by the importance of vertebrates in the diet of the loggerhead shrike (*Lanius ludovicianus*). Shrikes are prone to establish food caches, pinning dead prey on the thorns of various trees or on the barbs of fences. Examination of such caches has been a major source of information on the food of shrikes even though the function of the caches has never been fully understood. Food caches may vary in content from one item to dozens of items. One typical cache in central Illinois contained twenty-four mice, six snakes, a frog, and a grasshopper. The caches usually contain mice, most frequently voles (*Microtus*) and deer mice (*Peromyscus*), but also house mice (*Mus musculus*). They also often contain birds, house sparrows (*Passer domesticus*) being most frequent, but also such native species as juncos (*Junco hyemalis*), vesper sparrows (*Pooecetes gramineus*), field sparrows (*Spizella pusilla*), and bluebirds (*Sialia sialis*). The snakes most often found in shrike food caches are garter snakes (*Thamnophis*), and the frogs are probably mainly Hylids, especially *Acris*, though very few have actually been identified. The in-

Loggerhead shrike at nest (on left) and cache of shrike consisting of a house mouse on a locust thorn. (Photos by Richard Graber)

vertebrates that most often appear in the food caches are short-horned grasshoppers (Acrididae) and beetles, especially Scarabeidae.

Prey size in the caches is relatively large and seems to correlate well with the most commonly witnessed method of hunting by shrikes. Hawklike, the shrike looks for prey from an elevated perch or from the air, hovering, then shoots downward to capture prey on or near the ground. Shrikes also chase other birds relentlessly, but just how most of the birds are captured is unknown.

This is the way the shrike's food habits look from studies of food caches. Recently the opportunity presented itself to examine the stomachs of a number of shrikes collected for pesticide studies by William L. Anderson and James W. Seets. The stomach contents of the shrikes formed a picture of the food and foraging habits of Illinois shrikes notably different from that indicated by the food caches. The principal prey item in the stomachs, at least in terms of frequency of occurrence, was not mice, birds, or snakes, but small ground beetles (Carabidae) which occurred in from 40 to 80 percent (depending upon the season) of the seventy-one stomachs examined. Also prominent were caterpillars, which entomologist George Godfrey determined to be European corn borers (*Ostrinia nubilalis*). The prey items in the stomach that most closely paralleled the food cache data were the short-horned grasshoppers and scarab beetles. Vertebrates were much less frequent in the stomachs, varying from 0 to about 20 percent frequency, depending upon the season.

Not only was the food in the stomachs different from that in the caches, it implies a different method of foraging. Just how the shrikes get the corn borers is not clear, but the large number of small ground beetles in the stomachs seems to indicate that shrikes forage much of the time on the ground. Such foraging behavior would likely be much less visible than the hawklike techniques used to catch vertebrate prey and large invertebrates such as grasshoppers. The case is of special interest as an example of why it is so difficult to learn the truth about natural phenomena. An observer is led to one conclusion by observing the food caches and to quite a different conclusion from the examination of stomachs. Both sets of data undoubtedly represent some truth, but they leave us with unanswered questions about the shrike and its influence on other populations. The biological literature is replete with contradictions and paradoxes warning the scientist that every problem needs the careful application of all possible means of study.

Fishes, Keys, and Names

The arousal of public interest in the quality of the environment has precipitated several intensive pollution studies in Illinois and elsewhere by scientists in many agencies and universities. Before the scientist can develop a research program, he or she must know the names of the plants and animals in the study area. In studies of water pollution, the scientist will encounter fishes, and accurate species identification is, of course, imperative.

To enable the pollution worker to identify Illinois fishes, the Division of Fisheries of the Illinois Department of Conservation has just published a booklet entitled "A Key to the Fishes of Illinois with a Distributional Checklist." This publication, written over a period of several years by Survey ichthyologist P. W. Smith, should fill the need for an identification aid by professional biologists, students at both the high school and university levels, and interested amateur biologists.

A key is a document consisting of numbered couplets composed of contrasting statements. Its user selects the series of statements that best describes the specimen before him and then proceeds to the couplet number indicated in the right-hand margin until eventually he arrives at the name of the species. Many illustrations of structures or pattern-features of specimens in this key allow the user to recognize readily these items in the specimen he is attempting to identify.

The pollution worker and student can thus identify the 185 species of fishes that presently occur in Illinois waters. An appended distributional checklist gives the scientific and common names of each

Western corn rootworm adults. The difference in color between the sexes is highly variable, and the sexes are separated by the difference in antennae, rather than color. (Photo by Survey photographer Wilmer Zehr)

species and indicates where each is found in the state. The checklist also lists eight species that formerly occurred in certain parts of Illinois but have now been extirpated. The distributional data are the results of a ten-year cooperative study on Illinois fish populations by the Illinois Natural History Survey and Division of Fisheries.

Copies of this publication are available free of charge from the Division of Fisheries, Illinois Department of Conservation, State Office Building, Springfield, Illinois 62706. They may be requested by the title of the booklet or as Fishery Bulletin No. 6.

Corn Rootworm Disease

Two of the most important insect pests of corn are the northern and western corn rootworm. Adults of the corn rootworms are small beetles which in central Illinois begin to appear about July 1 and lay their eggs in the soil around corn plants from July 15 through September. These eggs diapause and remain in the soil in this dormant condition until the following spring. The eggs hatch about the time the corn seed begins to germinate. The corn rootworm larvae which hatch from these eggs feed on corn roots and, when numerous, can seriously damage the corn plant.

The actual number of corn rootworm eggs present in a heavily infested cornfield is astounding. Survey entomologists have calculated that such a cornfield may contain over 16 million corn rootworm eggs per acre. These eggs are no larger than the period at the end of this sentence, and yet if placed end to end, this number of eggs would span six and a half miles and collectively weigh over three and a half pounds. As is the case with most insect populations, natural mortality factors destroy most of the eggs or larvae of the corn rootworm before they develop into adults. As a part of the corn rootworm pest management program, Survey entomologists John Shaw, J. V. Maddox, and W. H. Luckmann are attempting to evaluate the mortality factors. These entomologists recently found a disease caused by a tiny Protozoan called a microsporidan in both northern and western corn rootworm adults. This is the first record of a microsporidan infection in the corn rootworm. The disease is transmitted transovarially, or through the egg from an infected female adult to her progeny. The microsporidan is also transmitted from one adult to another by small resistant forms called spores. The fecal material of an infected adult contains large numbers of these spores, and when ingested by another corn rootworm adult, the spores germinate and produce an infection.

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Although both species appear to be equally susceptible to the disease in the laboratory, the incidence of infection in field-collected adults is always higher in the northern than in the western corn rootworm. This is probably the result of congregating feeding behavior of the northern adults on corn silk, whereas the western adults are less selective in their feeding sites and often feed individually. The congregating feeding behavior of the northern corn rootworm adults increases the possibility of a healthy corn rootworm adult feeding on material contaminated by fecal material of an infected adult.

The disease occurs throughout the state, but the rate of infection varies greatly in adults collected from different cornfields. Over 90 percent of the northern corn rootworm adults from some fields was infected, while the disease was completely absent in adults collected from other fields. Field populations of northern corn rootworms with a high infection rate will contain numerous small adults, most of which are infected with the microsporidan.

Several fields which had a high percentage of diseased adults in 1972 are being monitored intensively through the winter, spring, and early summer to evaluate the effect of the disease on eggs, larvae, pupae, and emerging adults. It is possible that this disease is an important natural control factor of the corn rootworm in Illinois.

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Getting Together on Pest Management

On May 1, 1972, the National Science Foundation authorized the University of California's International Center for Biological Control to set up a large-scale pest management study as part of the U.S. International Biological Program. This major study will involve eighteen other universities, including the University of Illinois and Illinois Natural History Survey, and segments of the U.S. Department of Agriculture.

The principal objective of this study is to develop programs for integrated pest control that will utilize the most effective combinations of cultural practices, breeding for pest resistance, chemical control, and insect predators and parasites to optimize the cost/benefit ratio of control on a long-term basis. Such programs will benefit the farmer directly and will benefit society in general in various less direct but highly important ways.

Crops included in this study are cotton, alfalfa, citrus, coniferous trees, soybeans, and stone and pome fruits. Illinois scientists are cooperating in studies on alfalfa and soybeans, with Survey entomologist Ed Armbrust serving as leader of the alfalfa subproject and Survey entomologists W. G. Ruesink and Marcos Kogan cooperating on certain phases of the studies.

The alfalfa ecosystem is unique among field-crop systems in that it represents a relatively long lasting, well-established perennial system that exists nationally over a variety of climatic, geographic, and edaphic conditions. Because of these many subsystems, the interactions with other agronomic or natural ecosystems are equally as varied. Alfalfa supports a wide variety of insects, including destructive insects, pollinating insects, species that inhabit the fields because of the lush habit but have little effect on the crop, and many associated predators and parasites. Because of the perennial growth habit of alfalfa, many pests and beneficial insect species of other crops overwinter or build up in alfalfa fields before migrating to neighboring crops.

Since many potentially injurious insects that inhabit alfalfa fields are restricted by naturally occurring biological control, and many pollinating species are normally present, insecticides must be used with great care. The impact of pesticides on wildlife and the possibility of unacceptable pesticide residues in meat and dairy products must also be taken into account when applications of pesticides are included in a pest management system.

According to Dr. Armbrust, we cannot presently expect to control alfalfa pests with a single-factor approach. Predators and parasites alone will not control such economic pests as the alfalfa weevil, nor will the use of tolerant or resistant varieties. It will not be one factor, but an integration of many cultural, chemical, and biological factors, that will be important in the management of alfalfa pests.

Although the formal project on alfalfa pests has been initiated only recently, much information is already available and is being incorporated in integrated pest control programs. As more information is obtained by Illinois scientists and those in other cooperating states, control programs will be constantly modified to make the best use of the current knowledge on pest control.

All available tools, including computer models, improved sampling techniques, and breeding programs are being utilized to develop the most effective pest management systems. This relatively new, large-scale cooperative approach to pest control should result in the development of more effective pest management with less chance of adverse environmental effects than man has ever been able to achieve in the past.

Female Quail Accumulate Dieldrin

In recent years, many of the pesticides commonly used in crop protection have come under close scrutiny because of their adverse effects on wildlife. In particular, the use of chlorinated hydrocarbons such as aldrin, dieldrin, and heptachlor has become suspect since these materials leave persistent residues that are concentrated in the food chain in the ecosystem.

Although the use of aldrin is declining in Illinois, some 2 million acres are still being treated annually for control of soil insects. In the course of studies on the effects of pesticides on wildlife, Survey wildlife specialist W. R. Edwards recently analyzed tissues of bobwhite quail that had been exposed for fourteen days to soil treated with 2 pounds per acre of aldrin, the rate commonly used for control of soil insects in corn.

Six mating pairs of birds were placed in open-bottomed pens on treated soil and a similar number on untreated soil. The pens were moved daily so that no bird was exposed more than twenty-four hours on the same spot. Egg laying and nest initiation were recorded during the fourteen-day period. At the end of the two week exposure, all test birds were sacrificed and the tissues analyzed for chlorinated hydrocarbon content. Since aldrin converts to dieldrin in soil, and dieldrin accumulates in animal tissues, dieldrin content is used as a measure of the effect of aldrin treatments.

Results of the tissue analyses indicated that dieldrin accumulates in the female quail, particularly in the ovaries. No differences were detected in egg laying or nest initiation as a result of dieldrin accumulation, and no significant differences were found in dieldrin content in males from treated and untreated soil.

This pilot study indicates that female bobwhites acquire low but significant levels of dieldrin as a result of exposure to soil treated with normal rates of aldrin. Although no effects on reproduction were detected, this was a limited experiment of short duration. The accumulation of dieldrin in the ovary tissues of quail should be viewed with concern, and the possibility of adverse effects merits further investigation.

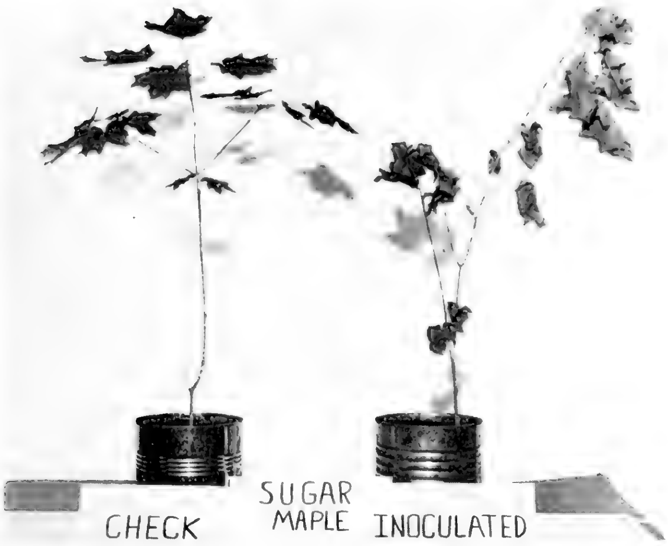
How Verticillium Gets into Trees

A soil-inhabiting fungus known as *Verticillium albo-atrum* invades the sapwood and causes wilting in many species of trees and other woody plants. Due to the wide host range and distribution of the fungus throughout the United States, Verticillium wilt is one of the most common and destructive diseases of trees and shrubs. Like Dutch elm disease and oak wilt, Verticillium wilt is an internal or vascular disease.

The disease is conspicuous because the leaves on affected plants wilt or turn yellow in early summer and die as the fungus, which usually invades the plant through the root system, spreads up the trunk and into the branches. Many trees and shrubs show wilt symptoms after they have been transplanted from nursery fields to landscape plantings.

Although Verticillium wilt is a common problem on woody plants, certain aspects of the disease cycle are not clearly understood. For example, does the fungus need a wound to penetrate the roots, or can it grow directly into the root? To understand how plants become infected, Survey plant pathologist G. L. Born conducted a series of tests using redbud and sugar maple seedlings, both of which are susceptible to Verticillium wilt.

Results of these tests showed that the fungus gains entrance into the vascular system through root wounds while bypassing the periderm layer of cells. Any injury serves as an infection court, but a wound deep into the vascular cylinder, which places the fungus in direct contact with the vessels, is more conducive to penetration by



Verticillium wilt symptoms on seedling sugar maple. Roots of the plant on the right were inoculated with the disease fungus. (Photo by G. L. Born)

the fungus. No infection occurred on unwounded roots.

The older the wound, the less chance for infection by the fungus. This may be correlated with growth responses by the plant at the wound site. Following wounding, a layer of dried cells forms on the surface of the wound. These cells died as a result of injury by the knife. Adjacent to the dead cells is a zone which becomes infiltrated with wound substances. This growth response results in a barrier that prevents the fungus from invading the functional vessel members. The sequence of wound healing may take place much faster on younger root tissue. Vigor of the host plant will affect the time in which root wounds heal over.

Research studies such as these provide information which can be used to improve control recommendations for plant diseases. For Verticillium wilt, good cultural practices should be followed when planting susceptible hosts in soil that may be infested with the disease fungus. When digging plant material, care should be taken to keep wounds to a minimum, and root pruning should be avoided. After planting, fertilizer and water should be applied to decrease transplanting shock and increase vigor of the plant. If the vigor of the plant can be increased, then the root wounds will heal more quickly, decreasing the chances of infection.

New Aquatic Study on Pesticides

Recent figures show that pesticides are being applied in increasing quantities on agricultural lands in Illinois. For example, the percentage of total crop acreage treated with herbicides and insecticides in the state increased steadily from 66 percent in 1969 to 74 percent in 1971. Several million pounds of pesticides were applied to 15 million acres of crops in Illinois in 1971. Additional quantities of these chemicals are used by local government units each year for abatement of pests such as mosquitoes and to control the elm bark beetles which transmit Dutch elm disease.

Through improper applications, spills, and erosion, significant quantities of pesticides find their way into streams, lakes, and ponds annually. Since these chemicals are present in the state's waters, Survey scientists have placed a high priority on determining what their effects might be on aquatic life.

Although some general studies have been conducted in the past, a new approach to the problem of pesticide effects on aquatic systems is being taken by a Survey team composed of entomologists Keturah Reinbold and R. L. Metcalf and aquatic biolo-

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gist W. F. Childers. Studies on the toxicities of selected insecticides and a herbicide used extensively in Illinois agriculture to a native fish species, the green sunfish, are being carried out in aluminum pools. These pools contain 264 gallons of water each and are models of natural ponds. They are placed outdoors where they are exposed to normal light and weather conditions and to the entry of aquatic plants and insects. During the winter months, the pools are moved into a plastic greenhouse which is heated enough to prevent freezing of the water but maintained at low winter temperatures. The combination of outdoor and greenhouse facilities allows studies to be made under year-round variations in light and temperature.

The information that may be gained under the special conditions of this research project should aid in making future recommendations for pesticide usage which are consistent with healthy aquatic environments. This project is of particular concern to fishermen and sportsmen interested in aquatic wildlife, to farmers who wish to maintain farm pond fishing, and to Illinois residents who use the state's waterways for recreational purposes.

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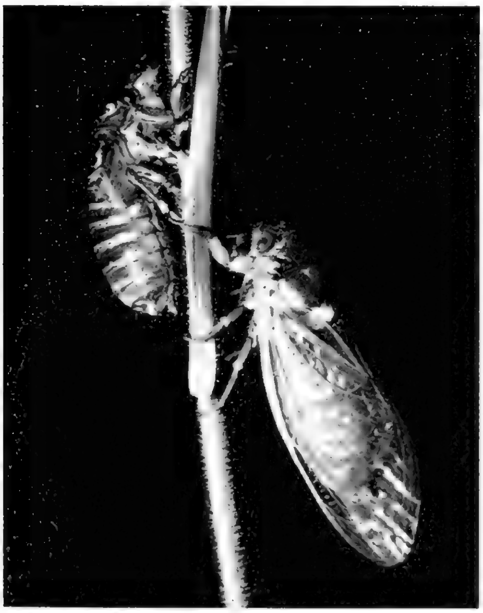
MAY 1973 NO 12?

Return of the Cicada

In 1956, Brood XIII of the 17-year periodic cicada emerged primarily in northern Illinois, eastern Iowa, and southern Wisconsin in enormous numbers. Scientists from Michigan, Illinois, and elsewhere came to our state to observe and study them. Hikers, school children, and mushroom hunters had to shout to make themselves heard over the din of the cicada's song. Some gardeners and horticulturists complained of the "flagging" of the trees where the twigs died after being nearly girdled by the egg-laying of the cicadas. From middle May through June the cicadas held sway and then no more — until this year.



Adult 17-year cicada and cast skin of nymph on twig. (Photo by Survey photographer Wilmer Zehr)

The return of one of Illinois' largest broods, mostly composed of two species of cicadas, one smaller and one larger in size will occur in 1973. Burrow holes will be seen in the forest floor in early May. Many of these holes will be covered with turrets. By the middle of May if the weather is favorable, the nymphs (which have spent the last 17 years underground feeding on roots) will crawl out of the burrows onto weed stalks or tree trunks, shed their skins, and emerge as adults. As many as 1,500,000 per acre might emerge from lowland woods whereas far fewer (130,000 or so) per acre may emerge from upland woods. By the end of May the male cicadas will be singing in unison, the wild birds will be engorging themselves on this abundant supply of insects, and then the female cicadas will mate and lay their eggs in slits sawn out by their ovipositor in the terminal twigs of trees and bushes. Finally the eggs will hatch and the young nymphs will drop to the ground, not to be heard from again until 1990.

Survey entomologists will be monitoring this brood once again to determine the decrease expected due to the cutting of forests and the recent urban sprawl over former cicada grounds, as well as to further test the hypothesis now being formulated that each brood of cicada occupies its own woods. The data gathered will be shared with other entomologists in other states to improve our knowledge of the entire populations of these species and to give those who make the observations in 1990 base data for future comparison.

Trace Elements and Pheasants

The possibility that a deficiency or excess of some chemical element might be preventing pheasants from extending their range southward in Illinois continues to be an intriguing research problem. In 1966 and 1967, with funds provided by the Illinois Department of Conservation, Survey Wildlife Biologists William L. Anderson and University of Tennessee Trace Element Analyst Peggy L. Stewart studied 24 elements in soil, grit, corn, and pheasants from good (Sibley), fair, and poor (Neoga) pheasant range. For that study, pooled samples of as many different environmental materials and as many different pheasant tissues as possible were analyzed. The findings, which were published in 1969 in the *Journal of Wildlife Management*, indicated that the inorganic chemistry of the physical environment and of pheasants differed appreciably in good, fair, and poor range in Illinois.

In more recent research, also funded by the Illinois Department of Conservation, Anderson and Stewart (now with Stewart Laboratories, Inc., Knoxville, Tennessee) attempted to progress from where their published work had left off, and most of their analytical work was conducted on individual samples. In 1968, they analyzed samples of unsorted grit and blood and livers from February-collected juvenile hens from Sibley and Neoga for 62 chemical elements. They found 28 of these elements in either the grit or the pheasant tissues. Continuing their research in 1969, they analyzed calcitic grit and blood and livers from August-collected adult hens from the same two areas for the 28 elements detected during the 1968 work. The findings for unsorted grit, calcitic grit, and livers indicated that, of the elements studied, a deficiency of sodium was most apt to be limiting the abundance of pheasants in poor range.

In an attempt to confirm the findings of the previous two years, Anderson and Stewart collected juvenile hens at Sibley and Neoga during February 1970, and analyzed livers, sternal muscles, and femur bones from these birds for sodium and four other major elements. However, confirmation did not occur. In 1971, still suspecting sodium, they analyzed femurs from the juvenile hens collected in 1968 and the adult hens collected in 1969 for sodium and the other four major elements. This work also failed to confirm that sodium was deficient for pheasants in poor range.

Second on Anderson's and Stewart's list of elements likely to be limiting pheasant numbers in poor range was barium. This trace element was six times more abundant in unsorted grit and 17 times more abundant in livers from February-collected juvenile hens, Neoga compared with Sibley. In early 1972, they analyzed for barium femurs from all of the hens collected during the more recent research and found that Neoga pheasants were carrying relatively high levels of this element. This was true for the juvenile hens collected during February 1968, the juvenile hens collected during February 1970, and the adult hens collected during August 1969. Thus, for the first time, these workers had uncovered a clear-cut difference between Neoga birds and Sibley birds for all three groups of pheasants studied. Because of these findings, Anderson and Stewart decided to analyze the femurs for the other 22 trace elements to determine whether any of these elements were also relatively high in the birds from Neoga. None was, which heightened suspicion that barium is limiting the distribution and abundance of pheasants in Illinois.

Anderson and Stewart believe that if an excess of barium is adversely affecting pheasants in poor range, the problem is complicated by low levels of environmental calcium. Such a relationship between barium and calcium would explain why pheasants occur primarily — *but not exclusively* — on recently glaciated (calcium-rich) soils.

Water Quality in Shelbyville

The Kaskaskia River and its two mainstream impoundments, Carlyle Lake and Lake Shelbyville, represent a major water resource in Illinois. Minor sources of pollu-

Survey biologists Ed Doyle and Jack Wurmnest taking bottom samples from Lake Shelbyville. (Photo by R. W. Larimore)

tion exist in the watershed, but most of these pollutes are quickly assimilated, and the river and its reservoirs are still relatively unpolluted.

In late April 1970, scientists at the Survey's Sullivan Laboratory on Lake Shelbyville began a water quality monitoring program, funded by the U.S. Army Corps of Engineers, to define preimpoundment conditions in the basin (closure of Shelbyville Dam was in August 1970), to investigate the effects of impoundment upon water quality, and to provide warning of degradation of water quality which should be controlled or might require restriction of water-use in the reservoir. Since its inception, this program has expanded to include a network of ten monitoring stations visited on a regular basis in the Lake Shelbyville basin. Nearly 15,000 separate analyses were performed during 1972! Recently the Survey established a similar ten-station network in the Carlyle Lake basin downstream from Lake Shelbyville.

Results to date have been compared to the State of Illinois Environmental Protection Agency's Water Pollution Regulations of Illinois by Survey Aquatic Biologist Allison R. Brigham in collaboration with R. Weldon Larimore. These general standards are intended to protect Illinois waters for aquatic life, agricultural use, primary and secondary contact use, most industrial uses, and also to guarantee the esthetic quality of the aquatic environment.

In general, Lake Shelbyville water quality measurements have been within the acceptable ranges of the established standards. With the exception of a minor spill of anhydrous ammonia in a tributary stream and a build-up of hydrogen sulfide in the deep water of the lake during the summer of 1971, the lake has been free of toxic substances.

Since we have become more aware of the role of nutrients, especially nitrogen and phosphorus, in contributing to nuisance algal blooms and, in general, the problem of rapid eutrophication, concentrations of these substances are important. Levels of nitrates in the lake are well below established limits. While total phosphorus exceeds the new, stricter standards, soluble orthophosphate, the form most readily available to the phytoplankton, is well below established limits in Lake Shelbyville.

Dissolved oxygen may be limiting to fish and other aquatic life in the deeper portions of the lake during summer. In fact, the benthic community which develops in Lake Shelbyville and other such lakes is composed chiefly of organisms able to withstand low concentrations of dissolved oxygen, such as midges and sludge worms, and organisms able to migrate to oxygenated water, such as the phantom midge.

Corn Pest Management

Integrated pest management has been practiced in Illinois to some extent for the past century. Forbes in his work on a chinch bug disease caused by a fungus pioneered some of this. LeBaron studied the wasp parasites of the oyster shell scale 15 years earlier than that. Since those studies of a century ago, Survey entomologists have studied insects, their life histories, and recommended methods of

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control. Methods of control involved adjustment of planting dates, tillage variations, harvesting techniques, and use of insecticides, along with imported parasites of foreign pests. Because of their economy, use of insecticides increased tremendously after World War II with the synthesis of many organic chemicals having insecticidal properties.

Knowledge about economic thresholds of insect populations on most crops was indefinite for most insect species, and applications of insecticides to avoid possible future damage became common practice as the public demanded more and better food uncontaminated by insect feeding. No longer could farmers gamble on yield losses of 10 to 25 percent. With this greatly expanded use came the question: By detailed insect population counts, can farmers have greater precision in insecticide application?

Cotton insect scouting is well established and growers actually hire young people to make these counts for them. Then the farmer himself, the county extension adviser, or some other agricultural authority interprets these counts as they relate to need for insecticide application.

In 1972 Survey and University of Illinois Extension entomologists, H. B. Petty and D. E. Kuhlman, began a corn insect scouting program in Boone County, Illinois, and John Zotz of Rockford visited 115 cornfields once each week to determine insect pest populations.

This year, the Illinois Cooperative Extension Service has enlarged this program with USDA Cooperative Extension Service grants. Mr. John Walt has been employed to supervise this program in the field. Warren, Hancock, and Shelby counties have been added to this study. All insect pests will be studied, but special account will be taken of wireworms, cutworms, corn rootworms, corn leaf aphids, corn borers, and grasshoppers. Nebraska, Iowa, Missouri, Ohio, and Indiana are developing similar programs for 1973. Eventually, it may be possible to accurately advise farmers whether or not these insects will be problems before the damage is done and without automatically applying a soil insecticide just in case.

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JUNE 1973 NO. 12?

Squash Vine Borer Control by Breeding

The squash vine borer is a persistent and destructive pest of nearly all squash and pumpkin varieties throughout much of North America. Production of suitable crops of susceptible varieties has nearly always required periodic applications of insecticides to control the borer. Recent research has shown, however, that it may be possible to breed natural borer resistance that occurs in wild cucurbits into cultivated varieties and provide adequate insect control without the use of pesticides.

The breeding of vegetable crosses resistant to insect attack has lagged far behind that of field crops. One of the most lucrative sources of insect resistance in many crop plants has been that found in cross compatible wild ancestors. Dr. A. M. Rhodes of the University of Illinois Department of Horticulture has crossed the Hubbard squash types with wild strains of cucurbits for many years using backcross and direct cross techniques. Although he was not searching for insect resistance when he made these crosses, the progeny were available for such studies.

During the course of investigations on genetic resistance to economic insects, Survey entomologist W. L. Howe recently tested many of Dr. Rhodes' crosses and found sources of resistance to the squash vine borer in successful crosses between susceptible squash varieties and a species of wild gourds. The fact that F_7 backcrosses and F_8 crosses were practically immune to squash vine borer damage indicates the dominance of this characteristic. Backcrosses have been made onto cultivated squash types for further selection during the 1973 growing season.

Since these crosses show resistance to the squash vine borer and in some cases to other insect species such as cucumber beetles and squash bugs, they may be entered into gene pools for the breeding of varieties resistant to insect attack. Selection for fruit quality and type among the resistant crosses will hopefully provide lines suitable for food production without the hazards of squash vine borer damage or applications of insecticides for borer control.

Squash vine borer larva in the stem of a Hubbard squash. (Photo by Survey Photographer Wilmer Zehr)

Calcium Barometers in Pheasants

The pheasant has established thriving populations on areas covered by the geologically young Wisconsin glacial drift in the Midwest but does not seem to do well on older drift. The first major hypothesis to explain this enigma was set forth by Aldo Leopold some forty years ago. He believed that a lack of calcium in the soils or plants on the older drifts was the limiting factor in preventing the establishment of pheasants in these areas. Yet today, after four decades of research, the precise role of calcium in delineating the range of the pheasant is still not clearly understood.

This volume of research has shown, however, that calcium is perhaps the most multifaceted element in the vertibrate body and as such can, in excess or deficiency, directly or indirectly affect the physiological balance of an animal. Thus an imbalance of calcium may be of critical importance to the well-being of the pheasant, but is the problem one of too much or too little calcium?

The parathyroids are endocrine glands that function importantly as regulators of calcium. High levels of circulating calcium act on the glands to inhibit the secretion of the parathyroid hormone; conversely, low levels of calcium stimulate this secretion. Because the circulating level of calcium is ultimately dependent on the dietary intake of the mineral, the size of a pheasant's parathyroid glands should reflect the amount of available calcium in the bird's environment. To investigate this relationship, Survey wildlife specialists R. F. Labisky and W. L. Anderson, who were already studying the organic and inorganic nutrition of the pheasant, carefully examined the relationship between the dietary intake of calcium and parathyroid size among penned, juvenile hen pheasants in the fall of the year.

They found that, after an eight-week feeding trial, the parathyroid glands of hens fed exclusive diets containing 14,000 parts per million of calcium were less than half the size of those fed diets (corn, for example) containing 40 ppm of calcium. Furthermore, in spring, the glands of wild adult hens from thriving populations were smaller than those of penned adult hens that had been fed diets containing low levels of calcium during winter.

Hypertrophication of the parathyroids in the pheasant, therefore, offers strong clinical evidence of a negative calcium balance. Thus, among pheasants, parathyroid glands can act as indicators of the levels of environmental calcium.

Hill Prairies a Thing of the Past?

On the sunny, windswept upper slopes of some bluffs along major streams are grassy openings clothed with prairie plants. These grasslands, when they occur on pronounced slopes, are defined as hill or bluff prairies. In Illinois, such prairies occur on the brow slopes of the bluffs of the Mississippi, Illinois, Rock, Sangamon, Fox, and Cache rivers as well as those of smaller streams.

Between October 1948 and February 1952, Survey plant taxonomist R. A. Evers visited sixty-one of the many hill prairies in Illinois, observing, making plot studies, and collecting plants. (The results of these studies were published in the *Illinois Natural History Survey Bulletin,* Volume 46, Number 5, 1955.) During the course of those field studies, he visited many of the sites only once or twice. To obtain a better knowledge of these prairies, he revisited some of them again in 1968 and 1969 and was impressed by the altered aspect in many cases. In April 1970, he began systematic visits to each prairie in the months of the growing season when visits were not made during his earlier studies.

On the first visits in 1970, seven of the sixty hill prairies were eliminated from further observations because they were no longer prairie. They had become dense thickets or woods, overgrazed pastureland, homesites, or were otherwise altered by man's activities. The original number was thus reduced to fifty-four for more detailed study.

Dr. Evers found that no prairie remained as it was twenty years earlier. The sites showed degrees of change from prairies to thicket or forest. Some exhibited little change with only a few forest species invading them. Others were strongly invaded

Prairie openings on a bluff southeast of Chalfin Bridge, Monroe County, Illinois, in February 1952. (Photo by former Survey Photographer W. E. Clark)

The same bluff in February 1972. (Photo by R. A. Evers)

and were mere remnants of once larger prairies.

Red cedar is a strong invader in this kind of prairie. It thrives on these dry, calcareous, sun-baked slopes. On some prairies it grew and spread tremendously during the past two decades. Prairie species could not tolerate its shade. Black locust, because it can root sprout, is also a very strong invader. Although an introduced plant in central Illinois, it has spread out from plantings, invaded openings, and has materially reduced the size of some bluff prairies. Two other common invaders were rough-leaved dogwood and smooth sumac. Some eighty-five other woody plants, trees

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or shrubs, invaded Illinois hill prairies in various locations.

Some plants of foreign origin were also invaders of hill prairies. White and yellow sweet clover were common in those which served as pastureland and some of the seed was, without doubt, planted. Multiflora rose grew in six of the prairies studied and Kudzu vine, which was possibly planted for erosion control, had smothered more than one-third of a hill prairie at Edgemont near East Saint Louis.

Man's activities, other than agricultural pursuits, are responsible for the loss of many bluff prairie stands. Removal of sand from a bluff north of Quincy destroyed most of the prairie plants. At two other sites the windblown glacial soil called loess, which had capped the bluff and supported prairie plants, was removed and used as fill for highway construction.

In March 1972, three of the stands had been burned, whether purposely or accidentally is not known. The fire had little effect upon the herbaceous plants of the prairie but destroyed the seedlings of trees and shrubs. However, the larger woody plants suffered little or no damage. They either sprouted from the base or produced leaves in a normal manner on the existing branches. In March 1973, two bluff prairies, one in Adams County and the other in Monroe, were found burned for the second time in two years. These stands will be closely observed to record the effects of two-year burning.

Apparently present climatic conditions favor forest rather than prairie and the area of hill or bluff prairie has been reduced in the past twenty years.

NOTICE: The July and August issues of the *Illinois Natural History Survey Reports* will not be published this year.

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SEPTEMBER 1973, NO. 129

Adult Eastern Gray Squirrel. (Photo by W. E. Clark)

Gray Squirrel History in Illinois

Gray squirrels were abundant in the forests of Illinois at the time of settlement. In primitive times, gray squirrel populations apparently attained much higher densities than today, according to Survey wildlife biologists Robert E. Greenberg and Charles M. Nixon. The historian of White County presented an account of a great "Squirrel Raid" which took place in 1834:

"In the fall of 1834 there was a great immigration of squirrels from Kentucky, which crossed the Ohio River by swimming, and made their way northward through Gallatin and White counties, overrunning the country and doing immense damage to the corn crop. They were killed in immense numbers by the citizens, especially as they crossed the rivers and were exhausted by the labor of swimming. They were then easily overtaken and slain by a club.

"In the neighborhood where Phillipstown is now situated, a number of citizens banded together to see how many they could kill in one day. . . . The men divided into two parties, of ten on a side, for the sake of competition. They were to scalp the squirrels, and meet at a certain place the next day (probably Sept. 10), and count the scalps. The result was 4,000 or 5,000 on each side. The defeated party, that is, the party surpassed in number of scalps collected, paid for the whisky used on the occasion, according to a previous understanding. They had a merry time; but they soon afterward went far beyond these numbers. They made up two parties again, and divided their territory by Crooked Creek. They made their raid on the poor but mischievous squirrels, and the day before Christmas they met and counted scalps, which numbered about 30,000 on a side!

"The squirrels were numerous for some years after this, but they gradually diminished, without renewal by general immigrations, until they reached their present (1883) scarcity. They seemed to have emigrated westward."

Kennicott, writing in 1857, also reported an "almost incredible abundance" of gray squirrels in pioneer times. He also noted that "this species appeared to increase in numbers, in certain districts, for a time after their settlement." But as large areas of prime hardwood timber were cleared for agriculture, the abundance and distribution of the gray squirrel declined, while that of the fox squirrel increased.

An examination of the distribution of forest land in 1820 provides insight into

the probable distribution of both gray and fox squirrels during the early nineteenth century. About 60 percent of presettlement Illinois was prairie, with forests found mostly along streams and in the unglaciated southern and northwestern areas. Within the prairie, forests extending along rivers provided some habitat for gray squirrels, but most of these woodlands were occupied by fox squirrels. Gray squirrels were rarely found in east-central Illinois in what is now Ford, Iroquois, Livingston, Grundy, La Salle, and McLean counties. It seems likely that fox squirrels were plentiful in areas where forest and prairie coexisted but were rare or absent in the heavily forested southern counties.

Isolated (relict) populations of gray squirrels in towns and parks today may be the remnants of former wild populations. This assumption is open to challenge in that there are known cases of successful urban introductions of gray squirrels by man. However, where isolated areas of forest (in 1820) coincide with present distribution of pockets of gray squirrels (such as the "Big Woods" in the center of Champaign County), it seems reasonable to accept these as remnants of formerly abundant wild populations of gray squirrels.

Continuous grazing and burning of many woodlots rendered them less suitable for gray squirrels and the gray squirrel was becoming relatively scarce in the 1880s and 1890s. Today gray squirrels are common only in the southern third of Illinois, and in some of the heavily timbered river bottoms remaining in the central and northern parts of the state.

Catfish and Bass Ponds

In southern states intensive channel catfish culture has been wedded to intensive sport fishing by catchout ponds or fee fishing areas. Information on management and angler success, however, has remained scarce in the literature. During 1970 aquatic biologists D. H. Buck, Richard Bauer and Russell Rose began researching the management of a channel catfish catchout pond to see if certain techniques could be implemented to benefit both the angler and the pond owner.

During the first two summers when only channel catfish were stocked, it was found that the larger fish in the population were caught more readily than the smaller fish and that fish reared in wire cages in the same pond were more easily caught after release than fish originally stocked free in the pond. Although the release of cage-reared fish improved the anglers' catch rate, there were still unavoidable slumps in angler success occurring at about the same time each year.

In 1972 largemouth bass trained to accept pelleted feed were stocked along with the channel catfish. In sixty-five fishing days anglers harvested 90 percent of the catfish and 83 percent of the bass stocked in the pond as compared to 42 percent in 1970 and 73 percent in 1971. It was felt that the unusually large angler harvest in 1972 was due primarily to competition between the two species. The same slumps in catfish angling occurred in 1972, but when the catfish refused to bite, the bass did bite, and vice versa. In this manner the bass maintained angler interest during the periods when catfish refused to bite.

Another advantage of this bass-catfish combination was that both species were maintained on a pellet diet throughout the fishing season. In addition to maintaining growth, the feeding program was used to manipulate the angler catch by feeding less when the catch rate declined and feeding more when the catch rate rose unusually high.

After viewing the success of adding a second species, and consequently more total pounds to the catchout pond, it is interesting to speculate on how far one might go with this type of management. If good fishing, and not necessarily good growth is desired, and if all species utilized can be maintained on artificial pellets, dense populations of diverse species may provide an answer to the growing demand for high yield, put-and-take fishing.

The James P. Nielson Insect Collection

Contributions to the Science of Entomology have often been made by ama-

Survey entomologists accepting collection from Mr. James P. Nielson. From left to right L. J. Stannard, D. W. Webb, J. P. Nielson, W. E. LaBerge.

teurs: doctors, lawyers, teachers, and schoolboys. The first collection given to the Illinois Natural History Survey was made by Cyrus Thomas (Carbondale schoolteacher) and Benjamin Walsh (emigrant English farmer of Rock Island). Among these amateur entomologists were the second Chancellor of the University of Illinois, Selim H. Peabody, who gave the Survey a substantial collection of beetles; Decatur's physician, Dr. Joseph P. Barnes, who donated a large number of moths and butterflies; and Carlinville's physician, Dr. Charles Robertson, who contributed his famed collection of bees.

These local collections of insects made by learned and thoughtful people, in their spare time and as an intriguing hobby, are more than just additions to the Survey's reference cabinets. The specimens represent a thorough picture of the fauna of that region, painstakingly searched for over many years and many seasons. As such they represent a good basic indicator of the fauna for future studies of change due to pollution or human activities on the natural conditions. They also are highly useful for studies on ancient insect dispersal back into glaciated areas, on regional evolution or on clinal adjustments to microhabitats, and on survival. On the basis of these amateur collections, Survey scientists have been able to monitor changes in the state every thirty or so years, one of the unique contributions to the natural sciences for which the Survey is noted.

The latest collection donated to our Museum has just come from Attorney James P. Nielson, Quincy, Illinois. Mostly hard-to-find and rare microlepidoptera (tiny moths), the collection of nearly 10,000 specimens represents Attorney Nielson's intensive activity over twenty years (1935-55) within a fifty-mile radius of Quincy in Adams County. Many of the species are new to our main collection, and all help round out the total data on

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the fauna of the state, especially in the western region.

Entomologists from the state, nation, and other museums of the world will be invited to study this collection to further our knowledge of the role of insects in the environment. These moths, despite their diminutive size, are not the least of the organisms that affect plants, animals and man in Illinois. Our appreciation and thanks are extended to Mr. James P. Nielson for giving the public his valuable collection of exquisitely prepared and carefully labeled moths and other insects so that science may profit from his labors.

Butterfly Directory

Butterflies are one of the natural wonders which come to the attention of nearly every person at sometime in his or her life. It may surprise the reader to learn that within the state of Illinois 146 species of butterflies have been recorded. A few of these records are of rare species, some of which may have accidentally strayed into this area or have been carried here by winds, animals, or man, and are not permanent inhabitants of Illinois.

Roderick R. Irwin, research affiliate of the Survey, and John C. Downey, University of Northern Iowa, have recently published an annotated checklist to the Illinois butterflies (*Illinois Natural History Survey Biological Notes,* No. 81, May 1973). In this checklist all Illinois butterflies are listed together with important locality records, distribution maps for most species, and other scientific notes. Three halftone plates of butterflies are an aid to the identification of some species.

Irwin and Downey point out that at least three species of butterflies have been extirpated from the Illinois fauna. Other butterflies which seemingly were not present in the state during early years of collecting have made their appearance in our fauna and a few have even become abundant. With the increasing alteration of the environment by man, it becomes ever more important to record conditions as they now exist and to document the records with specimens collected and deposited in recognized institutions for permanent care in order to be available for scientific use.

Copies of the butterfly checklist (*Biological Notes,* No. 81) are available upon request.

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New Insect Laboratory

Construction of an insect laboratory by the University of Illinois at Urbana-Champaign Department of Forestry was completed in July 1972 at the Dixon Springs Agricultural Center in southern Illinois. The laboratory is designed for basic studies on the biologies of insects attacking forests and ornamental trees in southern Illinois. Survey entomologist J. E. Appleby and University forest entomologist R. G. Rennels are cooperating on these studies. This laboratory will complement similar facilities located at Champaign-Urbana and in the northern part of the state at the Morton Arboretum at Lisle.

Climatic factors greatly alter insect activity. Because of the drastic variations in such factors between northern and southern Illinois, especially during the spring months, the life cycles of insects vary considerably between the different regions of the state. Regional information is needed as to the span of adult emergence, period of egg deposition, host plants, type of damage, duration of immature stages, number of generations per year, parasites, and predators. Such basic information is essential before control programs can be initiated.

A small nursery planting of ornamental trees and shrubs will be established adjacent to the laboratory. The plants will be infested with insects so that close observations can be made on insect behavior. The infested plants will later be used in control studies.

A permanent collection of lepidopterous insects injurious to ornamental trees will be made. Such a collection is valuable in comparative studies of species variation. It will be useful also as a reference collection for students, control personnel, and collectors.

Results of studies in progress and contemplated, at this laboratory and at the insect laboratories in central and northern Illinois, will be useful to nurserymen, homeowners, and forest land owners in insect recognition and control programs.

Location of insect laboratories in northern, central, and southern Illinois.

Trunk Treatment for Pin Oak Chlorosis

Yellowing of pin oak leaves, usually referred to as lime-induced chlorosis, is a major problem in alkaline soils in Illinois. Pin oaks are unable to obtain an adequate supply of iron from alkaline soils, and iron compounds must be applied to chlorotic trees to restore them to a healthy condition. Many methods of application have been used, including foliar sprays, soil treatments, and stem or trunk injections. Since iron is not transferred from old to new leaves, foliar sprays give only very temporary results. Soil treatments have been effective but results vary with soil type, moisture, and other conditions. Trunk injections have shown promise but the techniques developed were often too complex or involved special equipment which made the methods impractical for common usage.

Recently, Survey plant pathologist Dan Neely conducted a series of tests on chlorotic pin oaks in nursery and landscape plantings to evaluate a method of trunk treatment which involves implanting gelatin capsules containing iron salts into holes bored in the trunks of affected trees. Of the compounds tested, the two found to be most effective with the least amount of injury were salts of ferric citrate and ferric ammonium citrate. Chlorotic leaves of affected trees regained a normal green color within two to four weeks following treatment. Results thus far indicate that trunk implantations of iron citrate salts should correct lime-induced chlorosis for approximately three years, although rapidly growing trees may exhaust the implanted iron supply earlier. Since trunk implantation gives only temporary results, affected trees will probably have to be treated periodically for correction of iron chlorosis.

For best results, Dr. Neely suggests that chlorotic trees be treated in April, May, or June and that implantation be done using plastic cartridges available on the market for this purpose or that holes be sealed with doweling, cork, or asphalt after treatment. This is to prevent leakage and to protect tree wounds from invasion by insects and disease organisms. Treated trees should be watered immediately after treatment and during dry periods. For trees one to four inches in diameter at breast height, gelatin capsules containing .4 grams of iron citrate salts should be placed in holes two inches apart and at different heights on the trunk. For trees four to twelve inches in diameter, capsules containing 1.4 grams should be placed three inches apart and for larger trees they should contain 2.8 grams and be placed four inches apart. Implantations should be made in the trunk below the lowest branches for maximum distribution of iron in the tree.

Mineral Patterns in Goose Feathers

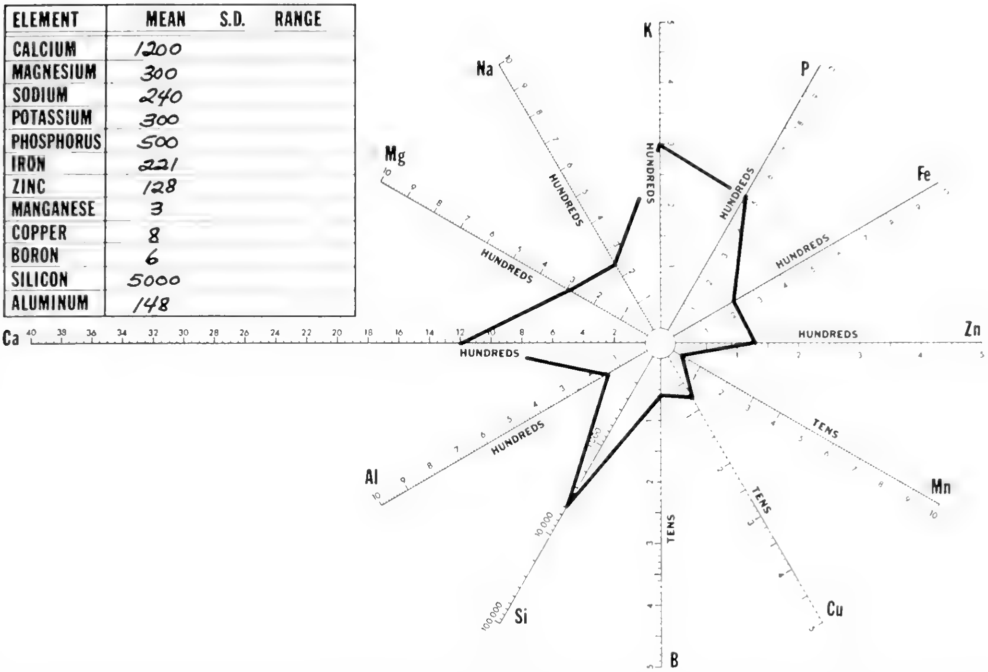
Most wild geese grow their flight feathers while in the vicinity of their breeding grounds. As these feathers grow, minerals ingested with the food and water become incorporated in the keratin of the feathers. The quantities of minerals ingested by geese reflect the mineralogy of the local ecosystem and the origin of the birds can be determined on the basis of mineral patterns of the main flight feathers or primaries. This correlation was pointed out in *Survey Notes* No. 115 in May 1972 by Survey wildlife specialist H. C. Hanson and Robert L. Jones of the University of Illinois at Urbana-Champaign Department of Agronomy.

Using the mineral pattern technique, the origins of as high as 85 percent of blue and snow geese were accurately determined. With races of Canada geese, which nest in regions with highly diversified geology, the feather mineral technique is even more accurate in determining not only origins but races or subspecies as well.

In a recent computer analysis of feather mineral patterns from 388 individual geese comprising seventeen races, 92 percent were correctly identified on this basis. Few taxonomists using common morphological characteristics could score as well.

Feather mineral patterns have also provided some unique and valuable insights into basic aspects of mineral metabolism. A study of twelve minerals in feathers of geese from breeding grounds spread over three-quarters of the North American continent revealed that levels of the bulk minerals calcium, sodium, potassium, and

ELEMENT	MEAN	S.D.	RANGE
CALCIUM	1200		
MAGNESIUM	300		
SODIUM	240		
POTASSIUM	300		
PHOSPHORUS	500		
IRON	221		
ZINC	128		
MANGANESE	3		
COPPER	8		
BORON	6		
SILICON	5000		
ALUMINUM	148		



Diagrammatic representation of mineral levels found in primary feathers of a snow goose. Geese from the same origin show similar patterns.

phosphorus appeared to be under metabolic control, although the levels also reflected environmental concentrations. The trace minerals, iron, manganese, and copper, and the inert minerals boron, silicon, and aluminum were apparently freely absorbed and more directly reflect environmental levels. Magnesium, a bulk mineral in the body which plays an important role (like the trace minerals) in enzyme activation, appears to be freely absorbed. Levels of zinc, a trace element, were under rigid metabolic control.

The question naturally arises as to whether rates of absorption or excretion are more important in regulating mineral levels. From these studies, excretion was judged the more important mechanism for all minerals except potassium.

The bulk minerals which are required in large quantities must be present in adequate amounts in the ecosystem or the birds would not be there in the first place, and metabolic systems have evolved to control the levels of these minerals. The trace elements, on the other hand, are generally in short supply and are absorbed freely, along with silicon and aluminum, since there was no need to evolve mechanisms for regulating their absorption. Levels of these minerals, therefore, reflect levels present in the ecosystem and are useful in determining the origins of geese.

In brief, feather mineral patterns have proven to be a valid reflection of mineral levels in the nutrient chain of the environment and provide valuable insights into mineral metabolism.

Predisposing Factors in Plant Diseases

When symptoms of injury or decline appear on trees and shrubs, the disturbed owner nearly always asks "What disease is affecting my plants and what should I spray with to cure them?" In most cases he is disappointed with the answer he receives from plant scientists since the majority of injuries are not due to disease organisms and only a few diseases of woody plants can be controlled satisfactorily with pesticide chemicals. More often the damage is caused by physical or climatic injury, toxic chemicals, insects, or in some instances by disease organisms that attack stressed or weakened

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plants but not vigorous ones. Such diseases can be very damaging to woody plants but surprisingly little is known about stress factors that influence disease susceptibility and how they can be reduced to keep plants free of disease.

Some of the reasons for this lack of knowledge are obvious. Plants growing under field conditions are subjected to many stresses during the year which may effect their susceptibility to attack by disease organisms. Usually these stresses (drought, freezing, and defoliation for example) are unpredictable and difficult to duplicate under controlled conditions so that their influence can be studied scientifically.

To better understand which stresses influence disease susceptibility in woody plants, Survey plant pathologist D. F. Schoeneweiss has developed methods for creating several plant stresses under laboratory conditions. Special chambers have been constructed in which field conditions associated with drought and freezing stresses can be simulated. In this manner the level and duration of these stresses required to alter disease susceptibility can be determined.

Results of this research indicate that stresses such as drought, freezing, defoliation, stem girdling, and transplanting shock can cause plants to become susceptible to certain diseases, even though the same plants are highly disease resistant when in a vigorous condition. In most cases, the level of stress required to affect a change in disease susceptibility is considerably less than that which results in injury in the absence of disease organisms. Thus stems inoculated with canker fungi and exposed to given levels of drought or freezing may form cankers, whereas these same plants usually recover from the stresses without ill effects if no disease organisms are present. These findings correlate well with field observations on the occurrence of diseases that appear to be related to environmental stresses.

Information obtained from research on stress factors that predispose plants to diseases should lead to improved methods of handling and maintaining ornamental plant material to reduce losses caused by disease organisms.

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NOVEMBER 1973, NO. 13

Lead in Aquatic Ecosystems

As part of an interdisciplinary study of environmental pollution by lead, a group of Survey aquatic biologists headed by R. Welden Larimore, John McNurney, and Tom E. Hill are studying lead distribution in the Saline Ditch drainage above Mayview, Illinois. This study is being carried on in cooperation with the University of Illinois. The Survey team is determining the distribution of lead in the fish, the aquatic plants, and the invertebrates in the study area, and measuring the movement of lead and characterizing the exchanges of lead between trophic levels in the system.

The lead distribution has been derived by measuring the size of the major plant and animal populations and their lead contents. Of the organisms of interest, only the drifting invertebrates constitute a measurable transport of lead through the study area and the amount of drift has been measured. Arriving at exchange rates between trophic levels is the most difficult assignment. Lead levels of individual organisms, experimental investigations of lead uptake and loss, and reviews of the biology of certain species have been employed to indicate the dynamics of individual accumulation mechanisms.

The use of lead in automotive fuels significantly influences the distribution of lead in aquatic ecosystems. The runoff characteristics and concentrated traffic volumes of an urban area cause high lead levels in primary drainage channels. The lead levels in aquatic organisms are substantially higher in urban drainage areas than in rural areas.

The concentrations of lead in organisms in any area of a stream are variable. There are fairly rapid changes in lead accumulation in organisms over short time periods. These fluctuations can be detected in areas

The saline ditch in an urban environment (Urbana). *(Photo by John McNurney.)*

where the tissue levels of lead are higher than 20ppm. Where large individuals are involved (more than 2.0 grams of wet weight) extreme, nonnormal distributions of individual lead levels can be discerned. There are wide variations in lead concentrations in different organisms from one area. The lead levels are apparently lowest in organisms which are high in the food web and not associated with the stream sediments and highest in organisms that are detritus feeders and closely associated with the bottom.

The dynamics of lead in aquatic environments can be further defined by investigating some of the aforementioned observations. A multiple correlation analysis of time-variable lead levels of organisms and measurements of environmental parameters is needed. A large population of some species of fish of sufficient size for individual analysis will be examined for lead content, size, condition, and age in an effort to understand the variation in lead levels. Some lab experiments and field investigations have been designed to examine the variation that exists between different organisms from the same area.

The distribution of lead in the aquatic organisms in an area can be adequately predicted. The dynamics of accumulation in particular organisms from one area and at certain times in one species are yet to be determined.

Rare and Endangered Fish

"Every living thing on earth is unique. Once gone, it can never be replaced. It is part of . . . 'the genetic pool' — the great reservoir of life on earth. . . . As passengers on this spaceship Earth, we'd be foolish to wipe out any of our shipmates." This quote from "A Law for Wildlife," published by the Conservation Department of Winchester-Western Division Olin in developing model legislation for state nongame wildlife conservation programs prefaces a brochure recently issued by the Department of Conservation's Division of Fisheries.

The fifty-three-page publication is entitled "Rare and Endangered Fish of Illinois." Its authors are A. C. Lopinot of the Division of Fisheries and P. W. Smith of the Survey. The objectives of the report are to identify the species of fishes in Illinois that are rare and/or endangered and to summarize the pertinent information necessary to preserve them. For each of the twenty-five species discussed, a line drawing of the fish with diagnostic characters indicated by arrows and a map showing both former and present distribution of the species are presented. A small inset map shows the distribution of the fish in the United States. The text includes information on characteristics, present and former distribution, range in Illinois, fecundity, reasons for decline, protective measures already taken, protective measures proposed, and management recommendations.

The new publication will alert fishery biologists, conservation organizations, and governmental agencies as to which native Illinois fishes are in greatest danger of extirpation and which streams, lakes, and swamps should be protected from dredging, channeling, damming, excessive polluting, and other modification by man that will hasten the disappearance of these fishes. It also outlines our present knowledge of the life histories of these species and points out aspects that need more intensive study.

A limited number of copies of this publication are available from the Division of Fisheries, Department of Conservation, Springfield, Illinois 62706.

The Pheasant: He Adds Green to the Economy

The pheasant is, without question, one of the most exciting and popular game birds in North America. Each autumn, hunters stream to the field to hunt this unpredictable long-tailed bird from the Orient. And, each autumn, these same hunters dispense a considerable amount of money in the pursuit of their favorite sporting adversary.

Just what does it cost for a hunter to bag a pheasant? Survey wildlife specialist Ronald F. Labisky and his Department of Conservation colleague William L. Preno decided to provide an answer to that question. They devised a questionnaire to solicit information on pheasant hunting costs from Illinois hunters, and encouraged their col-


Economic factors in pheasant hunting. *(Photo by former Survey Photographer W. E. Clark.)*

leagues in other midwestern states to use the same questionnaire for sampling their pheasant hunters.

The results! Illinois resident hunters averaged an expenditure of $16.50 to bag a pheasant in 1971. With an annual harvest of 957,000 pheasants, hunters contributed $15,790,000 to the Illinois economy in 1971. How did they spend it? The two big expenditures were for travel and dogs, accounting for 26 and 23 cents, respectively, of every dollar spent. Guns took 18 cents more of the dollar, whereas ammunition, food, and clothes absorbed 9 cents each; miscellaneous costs totaled 7 cents. License fees were not included in these cost analyses.

The cost per pheasant bagged by resident hunters in 1971 averaged $29.73 in Missouri, $17.42 in North Dakota, and $12.95 in Nebraska. In Iowa, resident hunters spent $15.11 to bag a pheasant, and nonresident hunters, $22.61.

The final step is to look at pheasant revenues in the United States. Labisky and Preno estimated that the 1971 harvest of pheasants in the U.S., which totaled 12 million birds, contributed about $225,000,000 to the nation's economy.

The pheasant is big business!

Almond Moth in Stored Soybeans

Millions of tons of soybeans are stored every year from harvest to the time they are moved for export or processing. While many stored grains such as wheat, oats, barley, and corn have very serious insect problems that require constant surveillance and special protection, stored soybeans in the United States, in general, do not. However, in other parts of the world such as Thailand and India the almond moth causes considerable damage. The almond moth does occur in the United States and has already been reported attacking soybeans that were punctured by stink bugs.

The almond moth is being studied under the direction of Survey entomologist Marcos Kogan. Mr. Sathorn Sirisingh, a graduate student from Thailand, is analyzing the conditions under which the almond moth is able to grow and reproduce on soybeans.

The moth is pale gray in color, one-fourth to one-half inch long. The head and tail are slightly raised and the wings are held in a rooflike position when the insect is resting. The larva damages grain. The caterpillars when fully grown are about three-fifths inch long, tinged with brown

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and faintly striped with darker dots. The young caterpillar spins a silken web formed into a little tube in which it lives and feeds. It is this web-spinning that causes the greatest amount of damage by the insect. The moth lays its eggs on soybean pods in the field before harvesting.

Mr. Sirisingh studied the development of the larvae in the green seed and found that larvae developed normally when the moisture content was between 50 and 60 percent. When the moisture content was only 25 percent, development dropped very sharply.

The moth cannot develop on beans that have a complete seed coat and a low moisture content. But if the seed coat is cracked the moth will develop even though the rate of development is slow at low moisture. Development of the moth improves when the soybean is boiled and dried. This is probably due to softening and cracking of the seed coat and to the inactivation of growth inhibiting enzymes in the seed. Developmental rates are near normal on soybeans put through a blender. This is of particular interest because new uses of soybeans for human consumption may require the storage of flaked or cracked soybeans. Partially processed beans are particularly susceptible to attacks.

Besides soybeans, this insect is known to be a pest of stored rice, peanuts, wheat, sorghum, maize, linseed, and sesame.

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DECEMBER 1973, NO. 132

Herons Reflect Environmental Quality

The use of birds as environmental sensors dates back more than a century, when coal miners used canaries to detect toxic gases in mine shafts. The birds fell victim to the gases much more quickly than humans did and, in this way, served as a special warning system.

In somewhat the same way, but on a much broader scale, bird and other wild animal populations are probably reliable sensors of environmental quality on a worldwide basis. If we are to use wild populations as indicators of environmental change, however, we need much better population data than we now have. For the vast majority of free-living populations, we lack even crude measurements for a single locality in a single year. With no better information than this, we can scarcely know that a given population has changed, let alone understand the causes of change.

Certain species of birds, the herons for example, seem particularly well suited as sensors. Herons represent the ends of several food chains, all associated with aquatic habitats that are also heavily used and often polluted by man. Most herons are also colonial nesters that return year after year to a traditional nesting place, which helps facilitate censusing once the colonies are located. In Illinois, the locations of some heron colonies have been known for years but the statewide population has never been determined.

In the spring and summer of 1973, Survey wildlife specialists Richard R. Graber and Jean W. Graber initiated a search to locate all the major nesting colonies of herons in the State of Illinois. Using aircraft and boats and by walking, they covered perhaps a third of the best habitat for herons in Illinois. Once the heronries were located, they were censused from the air, from the ground, or both. Counts of occupied nests and of young per nest provided data on productivity of the colony. Both population level and productivity of a colony are believed to be reflective of environmental quality. In addition, information on food habits of herons was acquired at some colonies. Because nesting herons have a habit of regurgitating recently ingested food when the colony is disturbed,

A great egret (one of several heron species) at a nesting colony near Plainfield, Ill. (Photo by Dr. J. W. Graber.)

samples of food could be collected from under the nests. These samples are being saved and can be analyzed later for the presence of toxic substances.

The heron survey in Illinois will be continued again next spring when the birds return. When all of the colonies have been located, their population levels, productivity, and food relationships will be monitored annually. These data are of value in relation both to the conservation of species and to the matter of environmental quality.

Treatment for Salt-Injured Trees

In the interest of safety, it is considered imperative that highways be maintained free of ice and snow. Therefore highway maintenance organizations have found it necessary to use large quantities of deicing compounds such as sodium chloride and calcium chloride. The rapidly increasing use of these deicing salts in recent years has had some detrimental effects on the environment, particularly on roadside vegetation.

Numerous reports indicate that trees along treated highways are less vigorous than those near highways where salts have not been applied, and in some cases are seriously injured or killed. These injurious effects are attributed to salt deposits from spray drift and to saltwater runoff onto the roadside soil.

Responses of plants to salt stress are manifest in numerous ways and are often difficult to assess visually. On deciduous plants, excess salts on the soil cause stunted growth, killing of terminal buds, twig dieback, leaf scorch, and, in severe cases, death of plants. Symptoms on evergreens may include needle burn and death of terminal buds and twigs.

Since most of our highways are already landscaped, the only ways to reduce salt damage are to reduce highway salting or go to the great expense of replacing present plantings with more salt-tolerant species. Whether trees injured by salt can be restored to a vigorous condition has received little attention in the past.

To determine if declining trees along heavily salted highways could be successfully treated to restore vigor, in 1972 Survey plant pathologist E. B. Himelick initiated a research project using combined mulching and fertilizing on hawthorn and green ash trees growing along the Edens expressway in Chicago. Four inches of wood chip mulch was placed around several declining trees of each species and the mulched trees were fertilized with ammonium nitrate in the springs of 1972 and 1973.

When the growth rate of treated trees was compared to that of adjacent untreated trees of the same species, a pronounced stimulation in growth was observed. Growth of treated hawthorns increased 39 percent in 1972 and 49 percent in 1973, while green ash increased 26 percent in 1972 and 22 percent in 1973. Visually, the treated trees appear in better vigor with decreased dieback of twigs when compared to trees receiving no fertilizer or mulch.

When available soil moisture is reduced, such as during a drought, soluble salt concentrations increase and can cause extensive injury. Since abnormal amounts of heavy rainfall occurred in both 1972 and 1973, the full effectiveness of the combined fertilizer and mulch treatments may not be determined until a normal season or drought season occurs. This study will continue at least one more year before the procedure is offered to the Illinois State Highway Department as a means of preventing or reducing further tree losses.

Fate of Diquat Herbicide in Lakes

Many diverse compounds such as the chlorinated organic insecticides, polychloro biphenyls, and various metals including mercury have been introduced into the environment by man. Although some of these compounds may be metabolized in the ecosystem, such as the conversion of DDT to DDE or inorganic mercury to methylmercury, all of these compounds accumulate in the environment. In light of the serious consequences that have resulted from these introductions, the federal Environmental Protection Agency has undertaken a review of many of the chemical compounds used as pest control agents, including those used as aquatic herbicides.

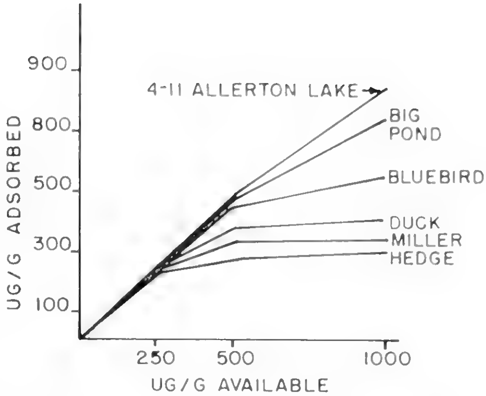
One of the most effective herbicides for

control of aquatic vegetation is diquat. Working with this compound in the past, Survey biochemist R. C. Hiltibran found that diquat provides control of some of the common aquatic plants. More important, however, it is effective against difficult-to-control species such as American elodea, southern naiad, and waterstar grass. To find out more about this herbicide and to determine how and where it accumulates, Dr. Hiltibran recently conducted an investigation of the interaction between diquat and the aquatic environment. This work was supported in part by a grant from the Water Resources Center of the University of Illinois.

Laboratory experiments, conducted in cooperation with research assistant Denny Underwood, revealed that diquat was not degraded extensively in water and could be detected in water for long periods of time. However, if diquat was introduced into a natural pond free of aquatic vegetation, it was rapidly removed and could not be detected after 72 hours. It appeared that the diquat was being adsorbed on the hydrosoil in the pond.

In cooperation with research assistant James Fickle, the adsorption of diquat by the hydrosoil from six natural bodies of water was investigated. These particular bodies of water were selected because they were of different ages and they represented aquatic systems influenced by gravel or coal stripping operations or damming of an existing water way. The binding of diquat by hydrosoils in the various waters was related to the cation exchange capacity of the hydrosoil and to a lesser extent the clay and silt content, but was not correlated with the organic content of the hydrosoils. The diquat adsorption on the hydrosoils in the different bodies of water are shown in the accompanying diagram. These studies also revealed that diquat could be readily desorbed or released from the hydrosoil from Miller Pond, which had a low cation exchange capacity, but not from hydrosoil from Allerton Lake, which had a high cation exchange capacity.

Research information of this type is needed in order to make intelligent recommendations for the use of pesticide chemicals in the environment.



Adsorption of diquat by hydrosoils from six different ponds or lakes.

Rootworm Management in Canning Corn

Three species of corn rootworms, the northern, southern, and western corn rootworms, attack sweet corn in Illinois. Only two of these, the northern and western species, cause significant damage in the northern half of the state where sweet corn is grown for the canning industry. The northern corn rootworm is well distributed in the state and has been around for some time, whereas the western species invaded the northwest corner of Illinois in 1964 and has spread rapidly throughout much of the northern half of the state since then.

These insect pests can cause severe damage by larval feeding on corn roots and, in some cases, by adult feeding on corn silk. In the past, rootworm control has been accomplished by the annual application of soil insecticides. Recently, however, Survey entomologist W. H. Luckmann, with the aid of research assistants J. T. Shaw and A. H. Redborg, has developed a pest management program for controlling rootworms in sweet corn grown for the Illinois canning industry. Insect pest management programs attempt to utilize as many biotic and cultural factors for control as possible, with a judicious use of insecticides.

In this program, the key to rootworm control is to plant sweet corn each year in the same ground and to design the

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planting schedule to coincide with the harvesting schedule of the previous season. The program is divided into four categories, depending upon the date of harvest the previous year, the planting date for the current crop, and the number and timing of sprays applied the previous year for corn borer and corn earworm control. Since insecticides used for borers and earworms are toxic to rootworm adults, applications of these insecticides can serve a dual purpose in corn insect control when integrated into this carefully designed program.

Details of this program will be presented to growers and canners before planting time this coming spring. In this manner, the growers will be able to design their own corn insect control programs, based on sound scientific knowledge, which will fit into their individual planting schedules. Thus canning sweet corn can be grown profitably with a minimum use of soil insecticides.

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Waterfowl Migration and Weather

With up to 2,000,000 ducks and 400,000 geese arriving in Illinois during the fall from northern breeding grounds, this state is one of the most important for migratory waterfowl in the nation. Most of the ducks pass through Illinois to winter in more southern areas, but most of the geese remain through the winter in southern Illinois.

The opening and closing of hunting seasons on waterfowl are established by the Illinois Department of Conservation within broad limits promulgated by the U.S. Bureau of Sport Fisheries and Wildlife. Therefore, it is important to determine the chronology of migration by various species of waterfowl to assist the Department of Conservation in setting the season at the most judicious time. This poses a real problem in a state 382 miles long, north to south.

Data obtained from aerial censuses of waterfowl in the Illinois and Mississippi river valleys, 1946-72, made by Survey biologist Frank C. Bellrose and his field assistant, Robert Crompton, reveal the chronology of passage for each important species each fall. The extremes in time of arrival between the years 1946-72 are: mallard, 20 days; pintail, 21 days; wigeon, 22 days; green-winged teal, 20 days; lesser scaup, 18 days; canvasback, 30 days; and ring-necked duck, 20 days. Departure dates for these species varied by a similar number of days among years.

If reasons can be found for the yearly variation in waterfowl passage through Illinois, the open season can be set more advantageously. The first step in seeking these reasons was an analysis of the influence of short-term weather conditions. This analysis indicated that short-term weather items were responsible for only

Canada goose migratory flight formation near Havana, Illinois. (Photo by former Survey Photographer C. L. Scott.)

4 to 47 percent of the arrival flights of the different species. These weather conditions influenced the late migrating mallards and canvasbacks most, the lesser scaups and ring-necked ducks least.

To supplement this analysis of weather and waterfowl migration, weather maps were studied in relation to dates that waterfowl were observed arriving or departing the Illinois and Mississippi river valleys. The relationship of duck departures from Fargo, North Dakota (equated to arrivals in Illinois) and from Peoria, Illinois with several types of weather fronts was studied. Slightly over half of the arrivals and departures occurred when fronts were not in juxtaposition to the departure area, and the frequency of departures appeared unrelated to the existing type of weather fronts.

Thus far, the evidence indicates that the yearly variation in the chronology of waterfowl migration is poorly correlated with short-term weather conditions. Additional study is needed to discover natural factors that will explain the variation in timing between years.

Mission: Information

Since communication through the spoken word is, by its nature not enduring, it is imperative that research scientists inform others of their findings in writing. Biologists at the Illinois Natural History Survey have been doing this for over a hundred years.

In Illinois in the mid-nineteenth century, formalized research recorded in print was just getting under way. As phrased by James Ayars, former technical editor at the Survey, "It was a time of rapidly expanding agriculture, hordes of hungry insects, and distressed and vocal farmers." Because research in applied science came along in answer to the needs of the time, most of it was biological.

Illinois was one of the leaders in making known the results of scientific research. Organization of the State Agricultural Society in 1853 and the Horticultural Society in 1856 opened important publication outlets to biologists. Reports of that era included such subjects as the origin and character of prairie soils, birds of the state, strawberry and tree culture, and the education of farmers' daughters.

Today the specific subjects number in the hundreds among five major areas of research at the Natural History Survey: economic entomology, aquatic biology, wildlife research, faunistic surveys and insect identification, and botany and plant pathology. And the "reach" of this information goes far beyond the borders of the state. The Survey's widely known library exchanges publications with about 700 libraries and other institutions all over the world.

In the days when appropriations were meager for the dissemination of research results, State Entomologist Stephen A. Forbes emphasized the folly of conducting investigations and neglecting the means to publish them properly. In 1886 he withheld his biennial report because funds were lacking to publish the paper and include pertinent illustrations. At its next session the Illinois General Assembly provided $300 for publication of State Laboratory of Natural History bulletins and $500 for illustrating the biennial report.

Special problems in handling biological information arise from its diversity of subject matter and approaches toward phenomena of the living world. Thousands of technical and scientific periodicals are devoted to biology alone, more than in any other field of science. Since biologists deal with some of the world's vital concerns, including the effects of man's activities on the environment, failure to communicate their research findings can have serious consequences.

The users of this information are many, including the scientists and scholars, the "practitioners," the policymakers or administrators, and individual citizens who need help with their everyday problems. The Illinois Natural History Survey issues publications in three major categories — scientific bulletins, technical reports, and popular circulars — and maintains an "Office of Publications and Public Relations," currently headed by O. F. Glissendorf. Their primary task is to aid the biologists in their preparation of about a dozen

Strip-mine ponds in Kickapoo State Park. (Photo by former Survey Editor James Ayars.)

Survey publications and some 80 to 100 articles for scientific journals each year.

Crawling Water Beetles

As man's awareness of environmental problems increases, the need for detailed physical, chemical, and biological environmental studies has become apparent. Such studies provide our only means of assessing existing environmental conditions and the ecological impact of resource development programs. Because the species, composition, diversity, and abundance of the biological community in an area provides a sensitive means of monitoring ecological changes, the ability to identify organisms accurately has become critical to the ecologist. The large number of investigations presently underway, however, precludes the participation of specialists in every project. In the resulting division of labor, a principal role for the taxonomist is one of providing identification aids to plants and animals for use by the nonspecialist.

To this end Survey Biologists Warren U. Brigham and Milton W. Sanderson have undertaken a taxonomic and ecological study of the water beetles of Illinois and adjacent areas. Presently their study has concentrated upon the crawling water beetles of the family Haliplidae. These beetles are generally less than one-quarter of an inch long and usually are yellow with black spots. Twenty-two species are known to occur in Illinois. Of these, two were unknown to science before the present study.

An interesting assemblage of haliplid species was discovered in the stripmine ponds of Kickapoo State Park, Vermilion County, Illinois (see photo). To date, fifteen species have been taken in the park, twelve from a single pond. This is nearly twice the number of species previously reported from a single locality in any part of the world. Stripmine operations in the Kickapoo area began approximately 100 years ago, shortly after prairie-marsh drainage became widespread. Apparently these stripmine ponds provided a refuge to the haliplids and other aquatic insects whose natural habitats were being destroyed. Refugia such as this one provide valuable information to the scientist regarding the once widespread prairie fauna of Illinois.

Pests of 1973 and Outlook

The twenty-sixth annual Custom Spray Operators Training School will be held January 9-10, 1974, in Urbana. During this

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meeting a report will be presented dealing with insect pests and their control in Illinois during the past year. This report, prepared by Survey Entomologists Roscoe Randell, Donald Kuhlman, and T. A. Cooley, is a summary of data received from county extension advisers in agriculture and includes comments on problems of the past year and an outlook for the coming season.

There is no normal year when considering insect problems; each season has its special troubles. Green cloverworms, corn rootworms, fall armyworms, and alfalfa weevils were the most troublesome agricultural pests in 1973. The major nonagricultural pests in Illinois during the past year were bagworms, roaches, spiders, and white grubs. For several years Illinois has had no catastrophic outbreak of pests as occurred before the advent of modern insecticides.

The green cloverworms were awarded the "insect-of-the-year" title for 1973. About 735,900 acres of soybeans were treated for this insect. Populations were extremely high in many fields in the northern two-thirds of the state during late July and early August. Fortunately, overall damage to soybeans was light, due primarily to a fungus disease and a parasitic fly which together decimated the cloverworm populations during early to mid-August. The green cloverworm overwinters in the pupal and adult stages. Two to four generations occur per year and a gradual buildup in populations occurs under good weather conditions.

Heavy infestations of fall armyworms were present in many fields of late-planted corn over the entire state in 1973. Late-planted fields of corn are preferred by the moths while egg-laying and are most subject to damage. The dark-brown to dull-green, smooth-skinned worms feed in the whorl, giving the corn plants a ragged appearance as the leaves emerge. Ordinarily, only one worm will be found deep in the whorl since the worms are cannibalistic.

Several instances of damage from common stalk borers occurred in no-till corn in 1973. Ordinarily, damage by this insect is confined to the border rows of conventionally tilled cornfields. In no-till corn, the infestations often covered the entire field or large portions of the field.

An estimated 7,194,618 acres of field crops were treated with insecticides in 1973, with a savings from crop losses to farmers of $24,018,473 above treatment costs. The control of soil insects in corn accounted for 80 percent of the estimated profits from using insecticides. Regardless of statements to the contrary, insecticides are clearly necessary for the profitable production of field crops in Illinois.

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New Lab Supports Water Quality Work

The impact of man's activities on environmental quality is a subject that has received much attention in recent years. Nearly everyone who reads the newspapers or watches TV is now aware of the deterioration of the environment. Increasing demands for more energy and greater food production mean that more and more waste products, chemicals, and other types of pollutants are being released into our air, soil, and water. How much can the environment absorb? It is obvious from the great controversies raging among environmentalists, governments, and industry that, although many people claim to have the answers, much factual information is still lacking.

Scientists at the Illinois Natural History Survey have been studying the natural resources of Illinois for many years and are in a position to obtain much of the information needed to evaluate the consequences of environmental pollution in our state. One of the areas in which changes in environmental quality can have pronounced effects involves aquatic systems. The close interrelationships between aquatic organisms and the quality of their environment have made these systems subjects for intensive study by the Survey staff.

With the opening of the Survey's new research annex at Urbana in December of 1972, an analytical chemistry laboratory was established, under the supervision of aquatic biologist Allison Brigham, to provide water quality data for the many research projects on aquatic systems at the Survey. The staff of this laboratory, in addition to their own research projects, coordinate surveillance work for the entire Survey and presently perform approximately 6,000 water analyses per month in cooperation with ongoing research projects. These include: (1) the aquatic studies portion of the Oakley-Sangamon Environmental Research Project; (2) water quality monitoring in the Lake Shelbyville Basin; (3) the continuous monitoring of water

An automated analyzer which is capable of making multiple water analyses without operator attention. (Photo by former Survey photographer Wilmer Zehr.)

quality in the series of experimental ponds established in connection with the new facility at Urbana; (4) the aquatic portion of an interdisciplinary study of environmental pollution by lead and other metals; (5) the aquatic portion of a study on nitrogen as an environmental quality factor; (6) the relationship between algae and eutrophication; and (7) the chemical factors affecting fish growth.

To maximize the efficiency of the laboratory staff while maintaining a high level of precision and accuracy, laboratory instrumentation is automated wherever possible so that a large volume of water-quality data is obtained. For example, the large autoanalyzer pictured in the accompanying photo is capable of performing six different analyses simultaneously on each of 100 samples without the attention of an operator. A computerized output is presently being incorporated into this system to provide rapid calculation and tabulation of data.

With the exception of heavy metal and pesticide determinations, which are performed in other Survey laboratories, staff members are able to analyze for most criteria of water quality. Other specialized capabilities include organic nitrogen determinations, total carbon analyses, and oxidation of radioactive samples for liquid scintillation counting. These combined capabilities make this laboratory versatile in its ability to perform a wide variety of analyses.

Additional computer analysis is applied to data generated by the larger projects of the laboratory. As a result, these techniques make it possible to quickly scan enormous amounts of water-quality data. This ability is important in detecting changes or trends in water quality. For example, the staff can be alerted to changes due to water impoundment or the degradation of water quality by pollution.

The Survey staff have recently expanded their research efforts to include a study to determine the effects of thermal discharges from a coal-fired generating plant on a 2,100-acre lake in central Illinois. They hope to characterize the effect of this additional heat on the annual cycles of nearly fifty physical-chemical properties of the water to see whether or not this waste heat exerts any adverse effect on the *normal* annual cycles observed in lakes. In addition, they are especially interested in determining if the unusual plankton community of the lake is a natural phenomenon or a community which developed in response to the use of lake water for condenser cooling. Over 50,000 individual measurements and observations will be made during the first year alone. Survey scientists feel confident that, with such data available, they will be able to make reliable recommendations relating to the effects of thermal discharges on the ecology of Illinois lakes.

Now that the energy crisis is here, with the probable relaxation of some environmental quality standards, our environment may be expected to absorb even greater quantities of pollutants. This means that the data on water quality being gathered at the Survey will be of increasing importance in the years ahead.

Toxicity of the Illinois River

In the period 1954-56, the fingernail clams died out in the middle section of the Illinois River. As recently as the spring of 1973, the clams had failed to recolonize areas where masses of dead shells indicated they formerly had been abundant. The tiny, thin-shelled clams are an important food for diving ducks and fish, and Survey waterfowl biologist Frank Bellrose found that diving ducks, which once migrated up the Illinois Valley, shifted their route to the Mississippi Valley, where the clams are still abundant. The species composition and the general condition of the fish in the Illinois River also indicate that serious pollution problems exist.

There are many factors that could affect the organisms in the river; silt, toxic chemicals, and low dissolved-oxygen levels, for example. The resources available to combat problems, including pollution, are usually limited, and the highest return per dollar, or effort expended to solve a problem, will be obtained if the most damaging components of the problem are identified and controlled first. In order to clean up a river, it is essential to know which factors

do the most damage, then to control these factors at the source, whether industry, municipality, or farm.

R. E. Sparks, Survey aquatic biologist, and K. S. Lubinski, a research assistant from Western Illinois University, are using chemical data generated by the State Environmental Protection Agency and the State Water Survey to develop a toxicity index for the Illinois River that may aid in identifying some of the pollutants that are damaging aquatic life in the river. The index may also be used to estimate the joint toxicity of several pollutants, an important consideration where organisms are exposed to many adverse factors acting in combination. The research is supported by the Water Resources Center of the University of Illinois at Urbana-Champaign.

The toxicity of chemicals known to occur in the river to a reference organism, the bluegill, is determined from bioassays reported in scientific literature or performed at the Survey laboratory on the Illinois River at Havana. Toxicity is measured in common units so that the concentration of a particular chemical at a given sampling location can be evaluated and the units can also be added to provide an estimate of the total toxicity at that location.

Based on chemical data obtained for a sixteen-month period in 1972 and early 1973, the toxicity index indicated that the upstream portion of the river is generally more toxic than the downstream portion, primarily due to higher levels of ammonia. Cyanide, copper, zinc, and lead occasionally contribute significantly to the total toxicity of the river. Total toxicity is within the range that could be expected to have long-range effects on fish.

The predictive capability of the toxicity index will be tested under field conditions this coming summer and may be modified on the basis of these results. It is possible that unknown pollutants, not presently measured, may be contributing to the toxicity. In addition, the relative importance of low dissolved-oxygen levels and silt will have to be assessed. Whatever the result, it is likely that additional bioassays and chemical measurements can reveal the relative importance of these factors.

Typical bark swellings on the trunk of a 'Redmond' linden tree. (Photo by Dr. D. F. Schoeneweiss.)

The ultimate goal of this project is to establish conditions in the river that are not merely sublethal for fish and other organisms, but that are conducive to maintenance of healthy, flourishing populations.

Linden Swelling

Many problems of trees and shrubs come to the attention of Survey plant pathologists each year. Most of these are readily recognized and diagnosed. A few, however, defy diagnosis even after intensive field and laboratory examinations. When affected plants show symptoms that indicate a possible disease condition, further studies may be initiated to find the cause and to determine whether control measures are warranted. In this manner, the pathologists are able to keep abreast of as many new problems as possible.

In late summer of 1971, a very unusual tree problem appeared in a northern Illinois commercial nursery in a field planting of 'Redmond' linden trees. The symptoms were large, corky swellings of the bark on 25 trees in one corner of a 534-tree nursery block. The swellings occurred in rows 6 inches to 4½ feet in length up and down the trunks, with the rows located below the lowest branches. Only an occasional small swelling was detected above any branch.

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An inquiry from the concerned nurseryman brought this problem to the attention of Survey pathologist Walter Hartstirn. Since no problem of this type had been previously reported on linden, Dr. Hartstirn made extensive examinations of affected trees in the field and in the laboratory. No known disease organisms were found and the symptoms suggested that the problem may be due to a virus or mycoplasma, or possibly to some type of chemical injury. If the problem is caused by a virus or mycoplasma, the disease might spread to healthy trees. Therefore the cooperation of the nurseryman was obtained so that the trees would not be removed, and an experiment was set up to try to determine the cause of the swellings.

Ten unaffected trees were budded with fifteen buds each from affected trees. Although the budding was successful, no swellings occurred and no evidence of transfer of a virus or mycoplasma was noted after one year. Since some viruses are known to move slowly in tree hosts, observations of the budded trees will continue for at least another year.

In addition to this experiment, the entire block of lindens was kept under close observation. Another affected tree was found in 1972 and three more in 1973. All of these were adjacent to the trees previously affected.

Since no evidence of a disease organism has yet been found, the possibility that some chemical is involved is also being investigated. Only one chemical was used in the block in its seven-year history but one other chemical could have leached from an adjacent farm field. Both of these chemicals will be applied to healthy trees during the coming year to see if they cause the swellings.

Keeping abreast of problems like this will not only add to our knowledge but may help avoid the spread of new diseases.

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MARCH 1974 NO.

Lice, Youth, and Schools

During the past several months, Survey entomologists have been receiving numerous inquiries about head lice and pubic lice. This winter at least six schools in Illinois have reported widespread infestations of head lice among young children and schoolteachers. Many older youths and college students have been plagued with pubic lice. Louse cases were generally very low in Illinois until the 1970s; now lice are becoming commonplace.

Human beings can be infested by three kinds of lice: the body louse (*Pediculus humanus humanus*), the head louse (*Pediculus humanus capitis*), and the pubic louse (*Pthirus pubis*). Some great apes and monkeys have closely related lice, but these are not found on man in this country. Body lice are not much of a problem here, probably because clothing (where the eggs are laid) are regularly cleaned and ironed by most families. Head lice, however, lay their eggs directly on the hair, and washing with mere soap and lukewarm water is not effective in destroying the lice or their eggs. Once an infection is present, especially in schools, the spread of head lice from child to child can be rapid as children often come into close physical contact in their play.

Adult head louse, *Pediculus humanus capitis*. (Photo by Survey Photographer Larry Farlow.)

By contrast, pubic lice never occur on the head but are centered in the pubic region, although they may range onto the hairs of the arms, legs, chest, and even beards. They do not occur on children. These lice are also spread by bodily contact, and infrequently from clothing freshly exchanged from infected persons.

Ordinarily lice cause mild itching and discomfort, referred to as pediculosis. Years ago, in the eighteenth and nineteenth centuries and even after World Wars I and II, relapsing fever was associated with human lice. So far, our current crop of lice has not introduced any fevers or diseases in Illinois.

In response to the many requests for control of lice, the University of Illinois Extension Service, in cooperation with the Survey, has prepared a fact sheet (NHS-105) describing these lice and the best methods to use to control them. These sheets may be obtained free by writing to the Survey. Survey Entomologist Steve

Moore III, head of the entomology extension service, recommends the use of 1 percent malathion or 5 percent carbaryl (sevin) as a safe control for lice on the head or in the pubic region. The treatment should be repeated in about ten days to destroy newly hatched lice.

Insecticides in Lake Michigan Mud

Organochlorine insecticides have been found to accumulate in tissues of fish in Lake Michigan to levels greater than the maximum recommended by the Food and Drug Administration in fish shipped in interstate commerce. The presence of these toxic, relatively stable products of our technological society threaten the very existence of the Lake Michigan commercial fishery.

Although a substantial number of data are available on organochlorine insecticides and their degradation products (principally dieldrin, DDT, DDD, and DDE) in fish from Lake Michigan, few published data exist on concentrations of these chemicals in the lake sediments. Survey Entomologist Willis N. Bruce, in cooperation with Harry V. Leland of the Department of Civil Engineering (University of Illinois at Urbana-Champaign) and Neil F. Shimp of the Illinois State Geological Survey, has recently published the results of a study of the distribution and concentrations of organochlorine chemicals in the sediments from the southern part of Lake Michigan (*Environmental Science*, Vol. 7).

The organochlorine chemicals are present in extremely low quantities in the water itself, but accumulate in the bottom sediments where they are bound chiefly to finely divided particles (clays) which are transported naturally into the deeper parts of the lake. The organic chemicals are stable in such situations, but they are picked up and concentrated in the fatty tissues of the organisms that live and feed in the sediment. These organisms in turn form a food source for larger predators (fish). Thus, the chemicals are moved up the food chain and are repeatedly concentrated until they appear in the tissues of larger fish in concentrations above five ppm (parts per million). In the present study, concentrations of all organochlorine chemicals together in the sediments ranged from a trace to over 36 ppb (parts per billion).

Data on the distribution of insecticide residues in sediments of Lake Michigan will have a direct bearing on methods devised for solving or mitigating the problem of residues in the future. This study will also facilitate additional studies of these chemicals and predictions as to their movements in biological organisms.

Green Sunfish Diet

Among the most popular sport fishes in Illinois are members of the sunfish family including small mouth bass, bluegill, redear sunfish, crappies, and green sunfish. Management techniques have been improved by many studies which have given us information on life histories of these fishes. Our ability to increase production of sport fish depends on the formulation of pelleted diets based upon the nutritional requirements of each fish. This has been done with great success for the channel catfish and the rainbow trout.

One of the most important nutritional needs of fish are proteins which consist of basic amino acids. Survey Aquatic Biologist George Lewis has been studying the amino acid requirements of the green sunfish to determine which of these are essential. An essential amino acid is one which the fish cannot synthesize but which must be incorporated in its diet.

A purified amino acid test diet used by previous researchers in trout and channel catfish studies was modified and used for this work. This test diet consisted of eighteen individual amino acids serving as the sole protein source. The remainder of the diet included white dextrin as a carbohydrate source, cellulose flour as a source of fiber, corn oil as a fat source, vitamins and minerals, and carboxymethyl-cellulose as a binder.

The qualitative amino acid requirements were determined by omitting a specific amino acid from the diet and comparing the average daily gains of fish to the average daily gains of those receiving the test diet containing all eighteen amino acids.

The green sunfish, *Lepomis cyanellus*. (Photo by W. F. Childers.)

Fish receiving diets lacking an essential amino acid did not grow and had average daily gains of zero or less. It was determined that the essential amino acids for the green sunfish are arginine, histidine, isoleucene, leucene, lysine, metheonine, phenylalanine, threonine, tryptophan and valine. It is interesting that these are the same ten amino acids required for growth in most juvenile domestic animals. The adult human and some adult domestic animals lose the requirement for histidine and arginine, but fish do not. This difference may occur because fish have indeterminate growth and mammals and birds do not.

With the development of this experimental diet, further studies can be undertaken to learn more about the nutritional requirements of the sunfish family. By deleting individual amino acids and adding them back to the diet in graded levels, quantitative requirements for optimal growth can be determined. Using the same methods, vitamin, mineral, fat, and energy requirements can also be studied.

Weather, Agriculture, and Rabbits

The feasibility of cloud seeding to increase rainfall in Illinois is being studied by the Illinois State Water Survey. For the ecological aspect of the study, Survey Wildlife Biologist Stephen P. Havera examined the relationship of weather and agriculture to the leading small game species in Illinois, the eastern cottontail.

According to information compiled by Preno and Labisky (1971), the Illinois cottontail harvest has been declining severely. The figures show a decrease of approximately 68 percent from 1956 to 1970. Wildlife biologists would like to know the reason for such a drastic decline. In most regions of Illinois, a July-August cloud seeding program would benefit production of corn and soybeans. Biologists would like to determine the effects of both an approximate 25 percent increase in July and August total precipitation and the relationship of acreages of corn and soybeans to populations of cottontails and other wildlife species.

To get an overall picture of weather-cottontail relationships, a total of nine monthly parameters for rainfall, temperature, snowfall, and sunshine were compared to the cottontail harvest from 1956 through 1970. A contiguous sixty-eight–county block of central Illinois that contains most of the state with the highest cottontail harvest and also most of the state's corn and soybean range was analyzed.

Results showed that weather factors in general were not highly correlated with cottontail data. The only weather parameter that appeared to correspond to the success of the cottontail rabbit harvest was total snowfall for December through March preceding the hunting season. The three years with the highest snowfall from December through March in the area studied (1959-60, 1963-64, and 1964-65) showed a corresponding noticeable decrease, and the years with lowest snowfall (1957-58 and 1965-66) showed a general increase in the rabbit harvest the following fall. Heavy snowfall can be expected to decrease the survival of breeding females,

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reduce the physical condition of females sufficiently to impair their reproductive capabilities, and reduce the amount of juvenile breeding, either by decreasing the survival of early season litters born in March or by delaying the initiation of the breeding season in February. It is doubtful that increased precipitation through cloud seeding in July and August not exceeding normal limits would have a direct effect on the cottontail harvest.

It was found that the principal reason for the drastic decline in cottontail populations in Illinois was habitat deterioration. Cottontails, like other wildlife species, require a suitable habitat to maintain their populations at desirable levels. No matter how favorable weather conditions are, rabbit populations will fail to maintain themselves without adequate food, water, and cover. In Illinois, there was a decline of almost 5 million acres of favorable habitat from 1956 through 1970 that paralleled the 68 percent decrease in the cottontail harvest during this period. Cottontail harvest had significant negative correlations with corn and soybean acreages, which increased by 3.5 million acres from 1956 through 1970.

Increasing acreages of corn and soybeans along with modern farming techniques and urban expansion are the principal reasons for our decreasing wildlife habitat. Precipitation enhancement along with the recent high prices offered for cash-grain crops may influence farmers to increase corn and soybean acreages which could further reduce wildlife habitats.

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APRIL 1974 NO. 14

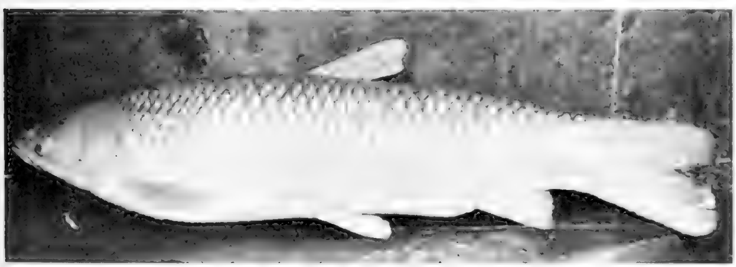
White Amur Controls Aquatic Weeds

The white amur, also known as the grass carp, is a member of the minnow family and is native to certain large rivers in Siberia and China. It spawns only in relatively fast-flowing streams and thrives on a variety of common aquatic weeds. The white amur is cultured throughout Asia and in parts of eastern Europe as a food fish and for its value in the control of noxious weeds. The culture of such exotic fishes is restricted in the United States because of the potential danger to native species, and the white amur cannot be legally introduced into Illinois. Two adults have been recovered from the Mississippi River, but there is no evidence of natural reproduction although the potential exists.

Survey biologist Homer Buck and his associates at the Sam A. Parr Fisheries Research Center began experiments in May 1973 to (1) measure the influence the white amur might have on associated fishes through its recycling of energies accumulated in the tissues of aquatic plants, and (2) to compare the biological control of plants by the white amur with control by a chemical means. The experiments were conducted in twenty plastic pools, each ten feet in diameter. Five of our commonest species of pondweeds were established in twelve pools, and a filamentous alga was established in eight pools. All pools were stocked with fingerling bluegills and golden shiners. Of the eight pools stocked with algae, four received white amurs, and four were left as controls. Of the twelve pools stocked with pondweeds, four were left as controls, four were stocked with white amurs, and four were treated with Karmex, a herbicide which kills many kinds of algae and higher aquatic plants.

By July 23 the effects on the pondweeds of both the chemical and the white amurs were obvious. The volumes of plant material in treated pools decreased rapidly, but plant densities in uncontrolled pools increased throughout the summer. By August 8 the white amurs had removed as much as 99 percent of the algae, and the growth of white amurs slowed thereafter, whereas growth by the associated fishes was accelerated.

In late September the weights of fishes, algae, and higher plants were inventoried. The total reduction of pondweeds by Karmex was 92 percent and by white amurs was 79 percent. Bluegill production was



The white amur or grass carp. (Photo by Wilmer Zehr.)

improved by either biological or chemical weed control. The greatest production of shiners occurred in the chemically treated pools, but the final average standing crop of white amurs was equivalent to 426 pounds per acre in pools stocked with waterweeds, and 371 pounds per acre in those containing filamentous algae.

Walnut Anthracnose Study

The eastern black walnut is one of our most valuable hardwood trees. The wood is widely used in furniture, gunstocks, and cabinetmaking, and buyers tour the countryside to bargain for individual trees. The distinctively flavored nuts provide food for man and wildlife. The black walnut grows throughout the eastern half of the United States, generally as scattered trees in fields, along fence rows, or in hardwood stands.

In recent years, however, intensive management of high-value hardwoods has become an accepted forestry practice. Many extensive plantations of black walnuts have been established in the north-central and Appalachian regions. Growing a single tree species in large plantations favors the rapid buildup of disease-causing organisms that would spread slowly in forests.

Walnut anthracnose, or leaf blotch, is a fungus-caused disease that is particularly destructive to the eastern black walnut. The disease may quickly become epidemic during wet weather in the growing season and cause many walnut trees to lose most of their leaves by late July or early August. This premature defoliation slows tree growth, weakens trees, and sometimes kills them.

Consequently, Survey Plant Pathologist Dan Neely has initiated a research program on walnut anthracnose. Dr. Neely has successfully conducted research on anthracnose of the sycamore and oak caused by fungi related to that causing walnut anthracnose. He and the plant pathologist working with him will conduct laboratory, greenhouse, and growth-chamber experiments at the Natural History Survey headquarters in Urbana. Field studies will be carried out in the Survey arboretum and on walnut plantations managed by U.S. Forest Service personnel stationed at Carbondale. Other study areas may also be used in the course of the study.

The Survey researchers will try to determine how light, temperature, moisture, pH, nutrient source, and substrate affect fungus growth, spore formation, and germination. Such knowledge may help in understanding the disease cycle and in selecting effective control practices. They will isolate the causal fungus from diseased trees and use the isolate in attempts to infect other trees of the same and related species, thus establishing the virulence of various fungus isolates and the susceptibility of various walnut species or hybrids.

The Survey plant pathologists and the U.S. Forest Service plant physiologists and geneticists will also attempt to discover the precise effects of the disease on tree growth and nut production. They will try to learn how and where the fungus overwinters, what conditions affect or regulate renewed growth or spore production, how spores are discharged and disseminated, what climatic factors affect foliage infection, how the fungus penetrates the leaf tissue, and what climatic factors affect the establishment of the fungus within the leaves.

The researchers will also test the effectiveness of fungicides, both as foliar sprays and as systemic fungicides that are injected into the tree or into the ground around the tree. When these studies are completed in about three years, we will have much more knowledge than we now have about walnut anthracnose and the economically feasible methods of controlling it.

Calling Bobwhite

Wildlife managers and researchers have for years attempted to estimate numbers of bobwhite quail. Two methods that have been used to estimate prehunt bobwhite populations are (1) censusing an area with bird dogs to locate coveys of quail and (2) adding the number of birds killed by hunters to the census figures obtained after the hunting season. The latter method was considered more reliable during periods of high quail population densities. However, both methods provide minimum estimates of the population.

Counts of whistling bobwhites also have

Bobwhite quail, *Colinus virginianus.* (Photo by Wilmer Zehr.)

long been used to indicate the relative summer abundance of these birds, but such counts were not satisfactory in predicting autumn quail populations. Now, however, Survey Wildlife Specialist Jack Ellis, former Survey wildlifer Keith Thomas, and Paul Moore of the Department of Conservation have found an apparently reliable predictor of the fall bobwhite population. Working on Stephen A. Forbes State Park in Marion County and on Sam Dale Lake State Park in Wayne County between 1964 and 1971, these researchers considered not only the number of bobwhites calling, but, more important, the number of bobwhite calls heard in a set time period.

Call counts were made at about weekly intervals along an established route in each park from mid-May to mid-July. Counts of two minutes' duration were made at each stop. The number of bobwhite calls and as many of the individual whistling cocks as could be distinguished were recorded.

In their analysis Ellis, Thomas, and Moore evaluated the number of bobwhite calls per listening stop, the prebreeding census data gathered in the field with bird dogs, and the number of whistling cocks as bases for predicting fall bobwhite populations. Census data were evaluated by using multiple correlation analysis performed by computer facilities of the University of Illinois, Urbana. Estimates for the prebreeding census, average numbers of bobwhite calls, and average numbers of whistling males were treated as independent variables, and the prehunt population estimates were used as the dependent variables.

Although data for only eight years were available, it was obvious that bobwhite call counts were closely correlated with prehunt bobwhite density, particularly on Dale Park. About 94 percent of the annual fluctuation in the prehunt population estimates for quail in Dale Park and 71 percent for Forbes Park were associated with changes in the prebreeding census and with the call counts.

Data for several more years and information from other areas are needed before final decisions can be made about predicting prehunt quail density from call counts. However, for now, these wildlifers conclude that on public hunting areas in southern Illinois carefully standardized call counts will provide reliable indications of the autumn abundance of bobwhites in the area censused.

Captan Tested in Model Ecosystem

As a part of a continuing program investigating the environmental fates of pesticides widely used in Illinois, the fungicide Captan has been examined by Economic Entomologist James Sanborn in the terrestrial-aquatic model ecosystem developed by Professor Robert L. Metcalf of the University of Illinois. Captan is used ex-

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tensively as a seed treatment for corn and soybeans and as a dressing on seeds planted by the home gardener.

The model ecosystem can be thought of as an Illinois farm pond surrounded by a watershed which is planted in corn. The laboratory ecosystem, which is housed in an aquarium, models this farm pond-watershed situation, as there are water and terrestrial segments. The water contains the organisms of a typical pond, including a fish, snails, mosquito larvae, algae, and *Daphnia* (tiny freshwater crustaceans). On the sand, sorghum is grown for the application of the pesticide being tested. Because Captan is used as a seed treatment, entomologist Sanborn mixed Captan in beneath the surface of the sand in which the sorghum was grown.

After thirty-three days the animals and plants of the ecosystem were examined for Captan residues. The data indicated that no residues of Captan were in the water, fish, snails, mosquitoes, algae, or *Daphnia*. This experiment with Captan in the model ecosystem corroborates the field data for this fungicide, as no adverse food-chain accumulation has been demonstrated after more than twenty years of the extensive use of Captan. Again, the use of this terrestrial-aquatic model ecosystem is validated as a useful method for determining the persistence and food-chain accumulation of pesticides.

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MAY 1974, NO. 137

Some Illinois Aquatic Crustacea

Among the important organisms considered in assessing aquatic ecosystem conditions and in preparing environmental impact statements are the Malacostraca (higher Crustacea). To facilitate development of statements for Illinois, Dr. L. M. Page has compiled a list of species of aquatic Malacostraca recorded for Illinois, citing references to their occurrence in the state and describing the habitats occupied and the distributions of the species within Illinois. The type-locality and a synonymy (alternative names used in the literature for the Illinois fauna) are also given for each species. The list will soon be published by the Illinois State Academy of Science and made available for distribution.

A total of 53 species of aquatic Malacostraca has been recorded for Illinois, four of them erroneously. Of the remaining 49 species, 13 are isopods (sowbugs), 18 are amphipods (scuds), and 18 are decapods (crayfish). Most species occur in restricted areas of the state, and only six of the 49 species are known to be statewide in distribution.

Thirteen species of aquatic Malacostraca were originally described from specimens collected in Illinois. Two isopods (*Asellus brevicauda* and *Asellus intermedius*) and a crayfish (*Orconectes illinoiensis*) were described from Union County, two amphipods (*Gammarus acherondytes* and *Gammarus troglophilus*) and an isopod (*Asellus packardi*) from Monroe County, an amphipod (*Bactrurus mucronatus*) and a crayfish (*Procambarus gracilis*) from McLean County, a blind isopod (*Asellus kendeighi*) from Champaign County, an isopod (*Asellus spatulata*) from St. Clair County, an amphipod (*Apocrangonyx lucifugus*) from Knox County, an amphipod (*Apocrangonyx subtilis*) from Jackson County, and a crayfish (*Orconectes immunis*) from Marshall County.

Preparation of the list of Illinois Malacostraca revealed the fauna to be very

Orconectes illinoiensis, a species of crayfish originally described from specimens collected in Union County, Illinois. (Photo by Survey photographer Larry Farlow)

poorly known. Long periods of time and much research need to be devoted to clarify the identification and relationships and to discover the ecological requirements of the Illinois species. Accordingly, a study of the present distribution, systematics, and ecology of the aquatic Malacostraca of Illinois has been started. Initially the investigators will be concerned primarily with reidentifying and curating the specimens presently housed in the Survey collection.

As time permits, field observations on natural populations are being made. During the past year, field collections added over 6,000 specimens to the Survey collection, including two species of crayfishes (*Cambarellus puer* and *Procambarus viaeviridis*) previously unrecorded for Illinois. Their occurrence in the state, along with new crayfish records for Kentucky, Indiana, and Missouri, were recorded by taxonomists L. M. Page and B. M. Burr in a 1973 issue of the "Transactions of the Kentucky Academy of Science."

Controlling Flies on Pastured Cattle

Face flies, horn flies, stable flies, and horse flies comprise the main fly complex attacking pastured cattle in Illinois, according to extension entomologist Steve Moore III. Populations of these flies were above normal in 1973.

An 18 percent reduction is a conservative estimate of the production loss (in weight gain or milk flow) caused by flies on pastured cattle during the summer of 1973 (Table 1). The stable fly, the least often recognized, caused the greatest loss. Eye problems were common in most herds when face flies were not controlled. The costs of eye treatments of permanent eye damage are not included in these loss estimates.

Increasingly, farmers are using insecticide dust bags for fly control. Farmers like the convenience (animals treat themselves) and relatively low cost.

Tests were conducted during the past three years with several insecticide dust bag formulations. Under ideal conditions for obtaining the best possible results, forced treatments with insecticide dust bags effectively controlled horn flies but failed to provide satisfactory control of face flies and stable flies.

Many insecticides applied as oil or water base sprays have been tested. The insecticide crotoxyphos is the most effective, as shown in tests in 1963. For best results. apply a 2 percent crotoxyphos spray at a rate of one to two ounces per animal two to four times per week, beginning about June 1 and continuing through early September. Treatments should be applied even when fly numbers are low, since crotoxyphos does not give quick results. Studies in 1973 with 1 percent crotoxyphos plus 0.25 percent dichlorvos spray applied at one to two ounces per animal daily gave satisfactory control of face flies and horn flies but did not effectively control stable flies.

Most farmers with beef or nonlactating dairy cattle on pasture are reluctant to adopt a spray program which requires frequently gathering, penning, and spraying the animals.

This past summer a herd of approximately 125 cows and 85 calves was treated every three days with a 1.25 percent dichlorvos water base spray applied from a tractor-mounted, mist-blower unit. The effective length of the swath was about sixty feet in still air. Nozzles were used to provide a coarse, wet mist. Approximately 3 ounces of spray were applied per animal per treatment. About 1 ounce or less of the spray actually reached each animal. About eight minutes were required to treat the herd. Total time for mixing and applying the insecticide and cleaning the sprayer was approximately thirty minutes. The treatments were applied in the pasture. Except for the first two times the animals were treated, they stood quietly during treatment.

The results showed the method to be highly effective in controlling the fly complex. Most farmers check their herds of pastured cattle every few days, and a fly control treatment could be applied easily at this same time.

Damage to pine shoots caused by the Nantucket pine tip moth. (Photo by former Survey photographer W. E. Clark)

Table 1. Potential Production Loss from Flies Attacking Pastured Cattle in Illinois in 1973

Fly species	*Production loss per fly per day, percent*	*Number of flies per animal, June-August*	*Production loss per animal, percent*
Face fly	0.15[a]	42.6	6.4
Horn fly	0.02[a]	37.3	0.8
Stable fly	0.7[b]	14.0	9.8
Horse fly	2.0[a]	0.7	1.4
Total	...	...	18.4

[a] Loss guestimate.
[b] Established loss (Bruce and Decker 1958. J. Econ. Entomol. 51(3):270-4).

Nantucket Pine Tip Moth

Nurserymen and forest managers in southern Illinois are concerned with the destruction of spring shoots of the loblolly, shortleaf, and Scotch pines. Damage is particularly severe to the terminal growth of young trees. Repeated injury of this kind causes stunting and crooked growth. The insect causing this damage is the Nantucket pine tip moth, *Rhyacionia frustrana* (Comst.). Although this insect occurs throughout the state, severe damage caused by it is limited to southern Illinois.

The insect overwinters as a pupa inside a damaged branch. The adult moth emerges during warm days in early spring and lays eggs on the needles or twigs. The eggs hatch in seven to ten days, and the larvae burrow into the bases of needles and later into the shoots. Larval feeding eventually results in the death of the bud or shoot. Several generations of this insect occur during the spring and summer months in southern Illinois.

Control studies were initiated at the Dixon Springs Agricultural Center to find insecticides that would control this moth. Field plantings of loblolly and shortleaf pines four to six feet high, showing severe symptoms of tip moth attack, were selected for the experiment. Foliar sprays of the insecticides dimethoate (Cygon), acephate (Orthene), oxydemetonmethyl (Meta-Systox-R), and Supracide were applied on May 3, 1973, when the larvae were very

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tiny and were feeding at the bases of the new shoots or just under the bark tissues. On June 11 the new shoots were examined for damage. All treatments resulted in excellent control with no injury to the foliage. Acephate and oxydemetonmethyl are presently registered for use on pines to control other insects but are not specifically registered for control of the Nantucket pine tip moth; however, dimethoate is registered for use on pines to control this pest. Supracide is not registered for use on pines. Future studies are planned throughout the summer to see if these insecticides will be as effective during other stages of the moth's development.

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JUNE 1974 NO. 1[illegible]

Grub Control in Turf Grass

Annual white grubs, probably the most common grubs found in sod, damaged many home lawns and other turf areas during the fall of 1973, according to Survey entomologist Roscoe Randell. Lawn damage was most apparent in September. This insect has a one-year life cycle, the eggs hatching in June and grubs feeding on grass roots until cold soil temperatures cause the grubs to go below the frost line to overwinter.

White grub damage was present in the fall of 1973 where chlordane had been applied in 1972. Instances occurred of poor control or no control from chlordane applications made in 1973 to moderately or severely damaged lawns. However, diazinon as a soil drench had been tried on grub-damaged lawns in 1972 with good success.

During September 1973, eighteen different lawn areas were treated for moderate to severe grub infestations. Chlordane, diazinon, Dursban, trichlorfon (Dylox), and Primicid were applied to one or more of these infested areas. Spray formulations of all five insecticides were used as well as granular applications of diazinon and Dursban. All treated areas were irrigated to soak the insecticides into the soil.

Chlordane at the application rate of five pounds of active ingredient per acre gave poor control of severe grub infestations. Primicid also did not control grubs. Dursban at four pounds of active ingredient per acre gave some control of grubs but not enough for recovery of the infested turf. Trichlorfon (Dylox) at four pounds per acre gave satisfactory control. Diazinon as a spray or in granular form provided satisfactory control of grubs, and recovery from damage had begun a week after treatment. Diazinon was applied at the rate of five pounds of active ingredient per acre.

Similar results were obtained when Survey entomologists Ralph Sechriest and Dan Sherrod tested six insecticides in the laboratory for control of annual white grubs. Grubs were placed in the bottoms of one-gallon ice cream cartons. One thousand grams of insecticide-treated soil were poured over the grubs, and a layer of sod was placed on top of the soil. Insecticides used and parts per million (ppm) incorporated with the soil were: chlordane, 2.5 ppm; diazinon, 2.5 ppm; Dursban, 2 ppm; trichlorfon (Dylox), 4 ppm; Aspon, 2 ppm; and Imidan, 2 ppm. Treatments were replicated five times. Live and dead grubs were counted every forty-eight hours, and live grubs were returned to the bottoms of the cartons. Diazinon gave excellent control of grubs in these small soil-

One of the white grubs found in lawns.

sample tests, and trichlorfon (Dylox) gave acceptable control. Diazinon and Dursban are labeled for control of grubs.

Elm Diseases

A twenty-nine-year study of the loss of elms in Champaign-Urbana to phloem necrosis and Dutch elm disease has been completed by Survey plant pathologist J. C. Carter and Mrs. Carter. The results of this study are being published as *Illinois Natural History Survey Bulletin,* volume 31, article 4. In this study, data were recorded on the spread of and losses caused by elm phloem necrosis and Dutch elm disease in a municipal area which had no community-wide control program for either disease.

Phloem necrosis appeared in the Champaign-Urbana area in 1944, when two trees were affected. Dutch elm disease did not appear until 1951, when one tree was affected. The initial spread of phloem necrosis was not influenced by Dutch elm disease, since Dutch elm disease was not present in 1944.

The early spread of Dutch elm disease was influenced by phloem necrosis because the elms killed by phloem necrosis were heavily colonized by the smaller European elm bark beetle, carrier of the Dutch elm disease fungus. Also, phloem necrosis–affected elms can harbor the Dutch elm disease fungus, and many of the phloem necrosis–affected elms were not removed before the bark beetles emerged.

The greatest number of elms affected by phloem necrosis in one year was 555 trees in 1952, eight years after the disease was discovered in Champaign-Urbana. The greatest number of elms affected by Dutch elm disease in one year was 2,116 trees in 1957, six years after the disease was discovered there. Of the original population of 14,103 elms, 2,994, or 21.23 percent, were killed by phloem necrosis in twenty-nine years, while Dutch elm disease killed 11,062, or 78.41 percent, in twenty-two years. Both diseases killed 14,048, or 99.70 percent, of the elms.

Current recommendations for the control of Dutch elm disease include the destruction of elm wood suitable as sites for insect infestation, application of an insecticide to protect healthy elms, and chemical destruction of roots to inhibit root-graft transmission of the causal fungus. Following the DDT controversy, widespread foliar applications of insecticides have become increasingly unpopular in urban areas, and new, environmentally acceptable control measures are being sought. Research evaluating the efficacy of the systemic fungicide benomyl (DuPont's Benlate) is being conducted at the Survey.

Benomyl has been registered by the Environmental Protection Agency (EPA) for use under defined, limited conditions. It has shown effectiveness in laboratory and greenhouse trials and now is being tested in the field. Foliar sprays were applied by plant pathologist Dan Neely to large nursery elms in the Survey arboretum in 1971, 1972, and 1973. Curative treatments have been more effective than protective treatments, but neither possesses an efficacy that warrants a recommendation for use. In only one test has the reduction in tree mortality been as high as 30 percent. Preventive insecticide sprays may reduce tree mortality by 75 to 100 percent. Application of benomyl suspensions into the soil throughout the root zones of large nursery elms has greatly reduced or prevented elm mortality in trees inoculated with the Dutch elm disease fungus. High rates of application are required, and this method of treatment is not registered by the EPA. Treatments made in 1971 remained fully effective against fungus inoculations in 1973, as did treatments made in 1972 and 1973. The ecological impact of benomyl in soil on elm roots, mycorrhizae, and earthworms is being studied.

Copper or Lead Shot

As our waterfowl resource continues to decline because of losses in habitat, increasing demands are placed on the remaining waterfowl resource. Lead shot causes substantial mortality of wild waterfowl each year, as Survey wildlife specialist Frank C. Bellrose reported in 1959. Lead pellets are picked up by ducks and geese and remain in their gizzards. There the lead shot disintegrates, and toxic lead enters the system

Survey wildlife specialist Frank Bellrose with ducks killed by lead poisoning at Rice Lake near Banner, Illinois. (Photo by George Arthur, Illinois Department of Conservation)

of the waterfowl. Therefore, in recent years there has been interest in finding a substitute for lead shot for use in waterfowl hunting.

Copper is ballistically a suitable substitute for lead in shot. However, before manufacturers proceed with expensive development costs, the effect of ingested copper pellets on waterfowl should be investigated. Survey wildlife biologists Glen Sanderson and Ken Walker and University of Illinois veterinarian Paul Beamer, with cooperation from the Winchester-Western Division, Olin, conducted a preliminary study of the effects of ingested copper shot on wild-trapped male mallards.

Eighty male mallards were placed in experimental groups of ten each, and each duck was given either No. 4 lead shot or No. 4 copper shot in doses of one, two, four, eight, sixteen, or thirty-two. The lead shot in the gizzard eroded much faster than did the copper shot. The rate of erosion of the copper shot remained constant up to 160 days, the length of the experiment.

Ingested copper may have caused the deaths of some mallards although the data are not conclusive. In surviving ducks, copper shot were retained in the gizzards longer than was lead shot, and the ducks were, therefore, subjected to a longer exposure to copper than to lead. Both mortality and weight losses of control ducks and ducks fed shot indicated that corn is an inadequate diet for wild mallards in captivity for a period as long as 100 days. Because of this dietary deficiency, the study did not demonstrate a conclusive effect of ingested copper shot on body weights of ducks, and this point needs further study.

Numerous cellular changes indicated that ingested copper was toxic to wild mallards on a corn diet in captivity. The most pronounced effects seemed to be on the liver and possibly on spermatogenesis. Although the results of this study are not conclusive because of the adverse effects of the corn diet, the study does suggest that copper shot is not a satisfactory substitute for lead in hunting waterfowl. Additional studies are needed before copper receives further consideration.

Aquatic Plant Control

With the construction of multipurpose ponds and lakes for uses such as flood con-

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trol, soil conservation, watershed management, and water supply, coupled with the increase in leisure time, more and more people are using these resources. To their dismay, reports Survey biochemist Robert C. Hiltibran, they often find that the water becomes inhabited by a variety of aquatic plants, ranging from small nonvascular plants, known as algae, to vascular plants capable of occupying the water space to depths of twelve to fifteen feet. It appears that many bodies of water are weed infested throughout the summer, and once infested, remain weed choked.

Drastic changes have been found to occur in the aquatic plant communities within a body of water in one year, and the aquatic plant communities may vary from year to year. Such changes in aquatic plant communities require corresponding changes in plant control methods. In contrast, in some bodies of water relatively little change in the aquatic plant communities has been observed and efforts to alter the aquatic plant communities have not been successful.

For example, attempts to eliminate curlyleaf pondweed from Mansion Pond at Allerton Park have not been completely successful. From 1960 through 1962 two stands of curlyleaf pondweed were eliminated each year. However, since 1962 curlyleaf pondweed, while present in Mansion Pond each year, has not been a serious problem.

These results, plus data obtained in many other bodies of water, indicate that the control of many aquatic plants is now possible. Although the initial cost of aquatic herbicides may be relatively high during the first few years, this cost coupled with that of the subsequent maintenance over the next several years, indicates that the overall cost of aquatic herbicides may not be great. The effort to control aquatic plants must be continuous so that plant infestations and the required amounts of aquatic herbicides will be small, reducing their impact on the aquatic environment. Thus, fishing and other water recreation, such as swimming and boating, become possible in one body of water.

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Modeling and Alfalfa Weevils

The alfalfa weevil, a native of Europe and North Africa, first appeared in Illinois ten years ago and rapidly spread throughout the state. Today it is our most serious insect pest of alfalfa. Although chemical control is essential for producing maximum yields, there are two other methods of reducing alfalfa weevil populations. One is to manipulate the timing of the first harvest in the spring. After consideration of many factors such as population size, plant growth, prevailing weather conditions, and so on, the cutting date can be timed so that the grower can achieve the same effect as applying an insecticide. The other method involves biological control agents, such as parasites and predators. One of the most successful biocontrol agents in Illinois is a small parasitic wasp, *Bathyplectes curculionis,* which lays its eggs inside young weevil larvae. Parasite larvae develop within their hosts, and when their developmental requirements have been satisfied, they kill their hosts.

The principal reason that we have a research program on alfalfa weevil control is that these three control methods are mutually interdependent. Insecticides kill parasites and predators as well as alfalfa weevils. Furthermore, the economics of considering three control methods simultaneously is complex. Slight changes in cutting dates may slightly reduce yield, but if the change benefits the biological control agents and reduces the weevil population, it may be financially advantageous.

Illinois is one of eight states cooperating in a nationwide project to develop and use mathematical models to help resolve the problems posed above and Survey entomologists E. J. Armbrust, W. G. Ruesink, and D. P. Bartell are involved in this project. In the process of developing the models, three kinds of biological research are required to support the modeling effort. One kind of research involves periodic sampling of the alfalfa weevil population to provide a data base against which to validate the models being developed. For the past year samples have been taken, sometimes as frequently as twice a week, from six fields in Washington County. Only one area of the state is being studied, in contrast to earlier projects, with the objective of reducing travel time and costs. The samples have been processed in our laboratory in Urbana, and the resulting data entered into files in the University of Illinois' IBM 360 computer.

Another kind or research involves a study of the population dynamics and the behavior of *B. curculionis.* It was discovered that nearly all past work lacked sufficient quantitative aspects. Consequently, we are looking at such things as survival rates of cocoons of the parasite (overwintering stage), longevity of adult parasites, and their reproductive potential.

The third kind of research involves developing new and improved techniques for measuring population densities of the alfalfa weevil and of *B. curculionis.* A technique of sweep net catches of adult weevils is being studied in order to forecast the best combination of control methods for the field in question.

During the coming year, we expect to complete the validation of our preliminary models and use these models to manage alfalfa production in our study fields. If successful, the program will be expanded to fields in other parts of the state and finally made available to all growers in the state via the extension service.

Power, Heat and Lakes

A cooperative research effort was funded by Commonwealth Edison Company in September 1973 to investigate the effects of their 1100 megawatt Kincaid Power Plant on the local environment and to gather data which could be used to predict environmental effects of cooling lakes at power plants that may be built in the future. Aquatic biologist Weldon Larimore is the director of this interdisciplinary study, conducted by the Illinois Natural History Survey, which includes basic research, applied research, and monitoring services.

Lake Sangchris, located in central Illinois, is a 2,700-acre impoundment that is used for cooling purposes by the coal-fired Kincaid Power Plant. Power plants alter the thermal characteristics of the lakes which they rely upon for cooling purposes. These increased water temperatures sometimes referred to as "thermal pollution" can be deleterious to aquatic environments. In addition, coal-fired power plants have the potential for emitting mercury and other trace metals into the environment when large quantities of fuel are burned. This study will help determine if thermal effluents are, indeed, deleterious to aquatic systems and whether trace metals and other by-products of the combustion process are serious environmental contaminants around power plants.

Morphologically, Lake Sangchris consists of three long narrow arms which converge near the dam. The thermal effluent of the power plant is circulated through two of these arms creating a temperature gradient. The third arm is relatively unaffected by the thermal effluent and serves as a control area for the investigations. This rather unique morphology makes Lake Sangchris ideal for studying the effects of increased water temperatures upon aquatic organisms.

Aquatic biologists Allison Brigham and Bob Moran are investigating the zooplankton and phytoplankton communities as well as monitoring thirty-five water quality parameters. Supplementary studies include phytopigment analyses, primary production measurements, and bacterial counts.

The spatial distribution of benthic organisms in relation to the thermal effluent is being studied by entomologist Don Webb. Artificial substrate samplers are being employed to help determine why so few benthic organisms are present.

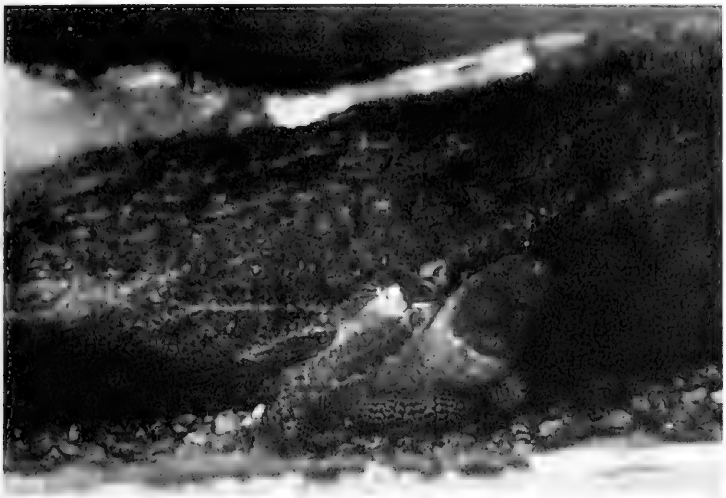
Aquatic biologists John Tranquilli, Rich Kocher, and John McNurney are studying the abundance, distribution, and behavior of fishes in various parts of the cooling loop. Growth rates, food habits, reproductive condition, and the incidence of parasitism are being investigated. In addition, radio-telemetry techniques and fish tags are being used to study the movements and behavior of largemouth bass.

A complete ecological study of mercury and other trace metals in the vicinity of Lake Sangchris is being conducted by wildlife specialists Bill Anderson and Ken Smith. This study involves collection and analyses of airborne dust, soil, lake sediments, aquatic macrophytes, fish, and waterfowl. Coal samples and samples of slag and fly ash are also being analyzed. Lake sediments are being analyzed for pesticide residues which might be adversely affecting benthic organisms.

The studies are being coordinated through the Lake Sangchris Laboratory, a new INHS field station located in Kincaid, Illinois consisting of an office and a laboratory for two resident biologists, space for storage of scientific equipment, and overnight accommodations for biologists.

Life History of the Spottail Darter

Among the native fishes of Illinois are two species of fantail darters restricted to rocky streams in the Shawnee Hills of southern Illinois. One of these, the spottail darter (*Etheostoma squamiceps*), was the subject of a life history study recently pub-



Spottail darters spawning in an aquarium. A nest of eggs is on the underside of the stone above the pair of darters. (Photo by L. M. Page)

lished by Survey ichthyologist L. M. Page as Illinois Natural History Survey Biological Notes No. 89. Copies of this publication may be obtained free by writing to the Chief, Illinois Natural History Survey.

Three years of field and laboratory observations on a population of the spottail darter in Big Creek in Hardin County, Illinois, revealed that the spottail darter primarily inhabits slabrock riffles and pools, reaches sexual maturity at one year of age, feeds primarily on aquatic insect larvae and crustaceans, and lives to a maximum age of slightly over three years.

Males attain a larger size than females and during the spring spawning season become much more boldly patterned than females. Most females spawn at one year of age but most males, although sexually mature at one year, apparently do not successfully spawn until a minimum of two years of age.

Spawning occurs from late March to late May or early June. As the spawning season approaches, the male spottail darter selects a cavity beneath a large stone as a future nesting site and vigorously defends it against intruders. When ready to spawn, a female joins the male beneath his nest-stone. After nosing about the stone for a time, the female rolls to one side and simultaneously rises to press her venter against the underside of the nest-stone. Usually almost immediately after the female inverts, the male rolls to one side and positions himself alongside and slightly overlapping the female, in an inverted head-to-head position. Pressed against the stone, the female begins quivering slightly, barely moving forward as she does so, and lays a series of two to five eggs on the stone. As she lays the eggs, the male trembles and releases sperm. Then both fish immediately return to a right-side-up position beneath the stone for a short time before courting by the male begins the sequence again. From 30 to 360 eggs are laid by each female, the larger females laying more eggs than smaller females. Several females may spawn with a single male, and nests having up to 1,500 eggs were found in Big Creek.

After spawning the female leaves and the male remains to guard the eggs until they hatch. The eggs hatch in five to eleven days and the young darters leave the nest.

Conditions and Stresses in Pheasants

The actions of toxins in birds appear to be strongly influenced by the physiological status of the specimens being studied. Thus, knowing whether test specimens are in positive or negative energy balance is minimal background information for any study of interrelationships between toxic substances and birds. In pheasants, it is well known that body weight and weights of muscular tissues and fat deposits undergo important changes as the birds pro-

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gress through the annual cycle. But how do these condition parameters respond to seasonal stresses the birds must endure to survive and reproduce? Survey wildlife biologist William L. Anderson attempts to answer this question in his recent Survey bulletin *Dynamics of Condition Parameters and Organ Measurements in Pheasants* by analyzing data for wild pheasants actively engaged in laying, incubating, or molting activities with statistical correlations. Copies of this bulletin (vol. 30, art. 8) can be obtained by writing to the Chief, Illinois Natural History Survey. Anderson designated body weight and weights of muscular tissues and fat deposits as the dependent variables, and the number of eggs laid, days of incubating, or number of primaries molted as the independent variable. The dates that pheasants were collected were also included in the correlations and were considered to be the second independent variable. Hence, the statistical tests evolved into multiple correlations.

With few exceptions, significant correlations existed between the condition parameters and the independent variables. Additional statistical tests were conducted to determine whether the first independent variable, or the second, or both, contributed significantly to the multiple correlations. Surprisingly, these tests indicated that the second independent variable, collection date, contributed as much or more to the correlations as the first independent variable. In general, the condition parameters for breeding and for incubating pheasants decreased in value, and those for molting pheasants increased in value, as the date advanced.

The reason that date collected would emerge as a dominant variable in dictating the changes in condition parameters of laying, incubating, and molting pheasants is difficult to pinpoint. Date alone is rather meaningless. However, many factors (e.g., photoperiod, temperature, precipitation, humidity, plant phenology, behavior and physiology of birds) can be associated with date, as well as with each other. In any event, the entire body, muscular tissues, and fat deposits of pheasants decrease in weight during the laying and incubating periods, and increase in weight during the molting period, as date progresses.

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OCTOBER 1974. NO

Illinois Still a Pheasant Power

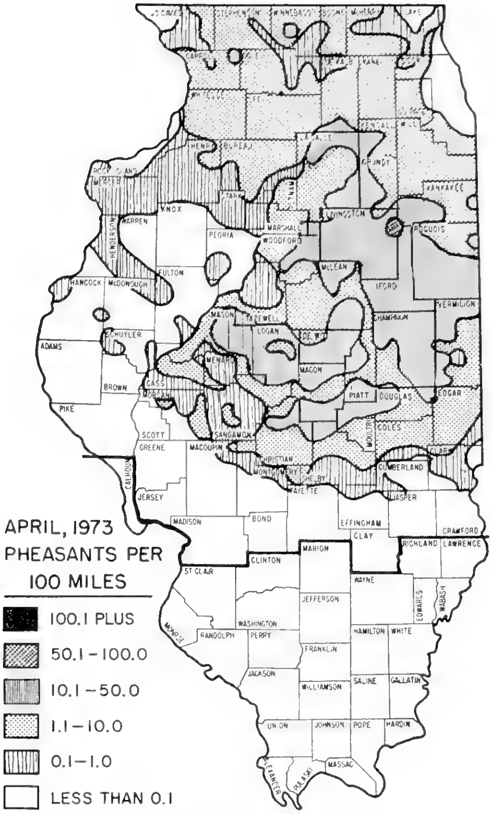
Keeping track of a state's pheasant population takes a staff of hundreds to do the job right. And that is exactly what Illinois has. Every five years, in April, about 800 postmasters and 1,200 rural letter carriers voluntarily assist Survey wildlife specialist Ronald F. Labisky in a census of Illinois pheasants. The postmasters distribute the census materials to the letter carriers, and the carriers count all the pheasants that they observe along their routes during a five-day period. In the last pheasant census, in April 1973, participating rural letter carriers drove 351,150 miles and observed 17,354 pheasants in the seventy-four northernmost counties of Illinois; wild pheasants are not found in southern Illinois.

The census revealed that the relative abundance of pheasants in the seventy-four northern counties had decreased from 5.5 to 4.9 birds per 100 miles of driving, or eleven percent, between April 1968 and April 1973. Comparatively, the 1958 and 1963 censuses yielded 7.6 and 9.9 pheasants per 100 miles. The 1963 population represents the all-time high in pheasant abundance for Illinois. Thus, pheasant populations in Illinois during the past fifteen years have exhibited a marked increase (32 percent) in abundance between 1958 and 1963 and a substantial decline (50 percent) between 1963 and 1973. Pheasant abundance, as recorded by these censuses, was 36 percent less in 1973 than it was in 1958.

Illinois's best pheasant range is still in the east-central sector of the state. The ten counties in which pheasants were relatively most abundant in April 1973, were — in order of rank — Ford, Livingston, Logan, Iroquois, Moultrie, De Witt, Champaign, McLean, Macon, and Piatt. However, the abundance of pheasants increased in only four — Ford, De Witt, Iroquois, and Macon — between 1968 and 1973.

Although pheasant abundance in the northwestern part of the state is still only about a fifth of that in our best range, excellent gains were made in Jo Daviess, Carroll, Stephenson, Winnebago, Whiteside, Ogle, and Lee counties between 1968 and 1973. Other counties that posted some encouraging gains in pheasant numbers included Mason, Christian, and Shelby. The discouraging news comes from the once-major pheasant counties of De Kalb, Putnam, Marshall, and Woodford, where pheasants were less than half as abundant in 1973 as they were in 1968.

Although about 11 percent more range was occupied by about 50 percent fewer pheasants in 1973 than in 1963, the effective change in pheasant abundance throughout much of Illinois's range was not as drastic as it appeared at first glance. To illustrate, Labisky points out that in 1963, sixty-one of Illinois's 1,612 townships contained more than fifty pheasants per 100 miles of driving; these sixty-one townships accounted for 53 percent of all pheasants observed in the 1963 census. However, in 1973 only one Illinois township had more than fifty birds per 100 miles of driving; it contained 1 percent of the pheasants observed in the 1973 census. In the final analysis, excluding the "hot-spot" townships, 15,021 pheasants were



Relative abundance of pheasants in Illinois

observed in 702 townships in 1963, and 17,181 pheasants in 849 townships in 1973. Thus, except for the lack of several high-density "hotspots" for pheasants in 1973, the general pattern of pheasant abundance in Illinois was about the same in 1973 as in 1963. This lack of change in the pattern of pheasant abundance may well explain the similarity in the hunter harvest of pheasants in 1963 (1,064,000 cocks) and in 1973 (1,073,000 cocks).

How does Illinois's pheasant population rank with that of other states? Labisky reports that Iowa is the number one pheasant state right now, harvesting about 2 million cocks each fall. Illinois, Pennsylvania, and South Dakota are competing for the number two position.

Training Bass to Eat Fish Food Pellets

In Illinois waters inhabited by largemouth or smallmouth bass, the average standing crop is about fifty to seventy-five pounds of bass per acre. The advantages of increasing this standing crop are obvious. One method that Survey aquatic biologists have tried is to feed bass various kinds of fish foods. The aquatic biologists have found that the standing crop can be increased to several hundred pounds of bass per acre by feeding them commercially prepared fish food pellets. Pellets are preferable to other foods because they are available at all seasons (unlike some natural food sources), they can be stored for months without loss of nutritional value, and they require less labor and thus less cost than do such bass foods as minnows, crayfish, or ground meat and liver.

Although some species of fish will readily feed on commercial fish food pellets, largemouth and smallmouth bass must be taught to feed on this kind of food. Homer Buck has successfully taught both species of bass to eat pellets.

Buck starts feeding small bass (one to two and one-half inches long) freshly ground fish, and then gradually over seven to ten days replaces the ground fish with small pellets. Bass have been trained to feed on the dry pellets by placing small bass in large tanks in the laboratory and by stocking large numbers of little bass in ponds containing no other fish. Buck reports that to get bass in ponds to feed on pellets, it is necessary to stock so many bass that they rapidly deplete the natural foods in the pond. When training bass in ponds, it is critical to start feeding them the ground fish and pellets when they have depleted their natural food supply.

Once bass are trained to eat pellets, they retain this training for long periods when they are not fed pellets. Trained bass in ponds are not fed during the coldest five months of the year (mid-October through mid-March); however, when the water warms during the early spring, they will immediately feed when offered pellets.

The question of whether trained bass could be used to teach untrained bass to eat pellets was investigated by William Childers. He obtained trained and untrained largemouth bass from Buck. Eleven trained and eleven untrained bass were marked, weighed, and measured for

Table 1. Percentage Increases in the Body Lengths of Trained and Untrained Bass Fed Minnows or Pellets.

	Pool #1	
	Fed Pellets for Forty Days	*Fed Minnows for Fifty Days*
Trained bass	15%	22%
Untrained bass	1%	25%

	Pool #2	
	Fed Minnows for Forty Days	*Fed Pellets for Fifty Days*
Trained bass	18%	30%
Untrained bass	18%	5%

length (average, 3.82 inches), and were then stocked outdoors in a plastic wading pool ten feet in diameter. Another plastic pool was stocked with the same number and size (average length, 3.84 inches) of trained and untrained bass. The twenty-two bass in one pool were fed fat-head minnows, and the bass in the other pool were fed dry fish pellets. After forty days the fish from both pools were measured and returned to their respective pools.

During the next fifty days the bass which had been fed minnows during the first forty days were fed pellets, and the bass which were fed pellets in the forty-day period were fed minnows.

The results of this experiment are summarized in Table 1. The minute length gains made by the untrained fish when being fed pellets are explained by the fact that small supplies of natural food sources (insects, etc.) were available in these outdoor pools.

The results of this experiment were rather surprising. The untrained bass had very little naturally available food to eat when they were being fed pellets. They must have become extremely hungry and therefore highly motivated to seek food sources. They must have observed the trained bass eating the pellets. In spite of these conditions, the untrained bass would not eat the pelleted food. Future experiments are planned to determine how the age and size of bass affect their ability to be trained to eat pellets.

Trees Without Disease

Every year thousands of people call or send twig, bark, and leaf specimens to the Section of Botany and Plant Pathology seeking advice on their trees. In many instances a tree is diagnosed as having a "terminal" disease. Since trees are long-lived plants, it is often difficult for the homeowner to accept the fact that his tree will die and should be replaced with another.

Plant pathologist Gene Himelick says that most tree diseases and other tree problems can be prevented. One should give considerable thought to the selection of trees.

Of the more than 300 tree species used for shade and ornamental purposes in Illinois, only about fifteen to twenty have been widely planted. The following trees are among those most frequently planted and most commonly affected by disease problems — American elm, pin oak, American sycamore, white oak, some crabapple and hawthorn species, and Russian olive. (Some crabapple and hawthorn species are resistant to diseases that commonly affect these trees.) White birch and honey locust have insect problems which can weaken or kill the trees. In Illinois the above tree species are seriously affected by at least one disease or insect problem and should be planted in very limited numbers.

The following factors, listed in the

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order of importance, should be considered in selecting trees:

1. Cold hardiness
2. Resistance to serious disease and insect problems
3. Adaptability to soil conditions
4. Mature height and width of crown
5. Susceptibility to drought, ice, and wind damage
6. Ease of transplanting
7. Appearance of flowers, fruit, bark, and leaves
8. Availability
9. Rate of growth

Because trees represent a considerable investment, they should be maintained in vigorous growing condition, and a good maintenance program should be considered when selecting trees. A well planned landscaping program will increase property value, lower future tree maintenance costs, and give protection from sun, wind, dust, and noise. Trees are too often taken for granted, and little thought is given to them until they die or become damaged and must be removed.

Many tree species can be substituted for those trees which have serious problems. The number of substitutes readily available from nurserymen often is not great, but in time public demand will stimulate nurserymen to propagate and supply the species needed.

Tree species relatively free of problems are: European black alder, ash (selected species and varieties), European beech, amur cork tree, crabapple and hawthorn (selected for disease resistance), dogwood (special flower selections), Chinese elm (*Ulmus parvifolia*), Douglas fir, concolor fir, ginkgo (male only), black gum, sour gum, sweet gum, hackberry, European hornbeam, hop hornbeam, Crimean linden, littleleaf linden, magnolia, red maple, Norway maple, sugar maple, English oak, red oak, Bradford's Callery pear, red pine, Scotch pine, white pine, London plane tree, purple leaf plum, redbud, hardy rubber tree, sassafras, spruce, and tulip tree.

A final caution: some of these trees thrive well in only parts of Illinois. Some do not grow well in clay or in the disturbed soil that is sometimes present around newly constructed homes and along streets.

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NOVEMBER 1974. NO. 14

Scorpionflies Roam the Midwest

The order Mecoptera is considered among the oldest and most primitive of holometabolous insects. Fossils are known as far back as the Permian. Generally they live in mesic areas, especially among dense herbaceous vegetation in lowland woods. One genus, *Boreus,* occurs in ground moss with its adults active only during the winter months.

The major center of distribution of Mecoptera in the United States is in the Southern Appalachians, from which area the various species have dispersed themselves northward and westward. Of less than 500 species of Mecoptera known in the world, eighty occur in North America and eighteen can be found in Illinois.

Over the past five years Survey entomologists D. W. Webb, N. D. Penny, and J. C. Marlin have collected Mecoptera from every county in the state. The objective of this study was to update our knowledge of the distribution and natural history of Mecoptera, particularly in relation to the biogeographic history of Illinois.

Of the four Midwestern families of Mecoptera considerable variation is exhibited in their habits and life cycle. The Bittacidae, or hangingflies, are predaceous. Hanging by their forelegs from the underside of vegetation, they wait with outstretched hindlegs for some unsuspecting prey. When a prey is within reach, it is seized by means of the hind legs folding over the prey. Larval bittacids are relatively active and can be found among ferns and moist leaf litter feeding on dead or dying animal matter. The Panorpidae or true scorpionflies are saprophytic, feeding on dead or dying insects. They are found moving about on low herbaceous vegetation, in particular stinging wood nettle or jewelweed. Larval panorpids live in the soil through which they move in search of food. The Boreidae or snow-scorpionflies are wingless and are found

A hanging fly, *Bittacus pilicornis,* awaiting prey (Photo by former Survey photographer Wilmer Zehr).

in and around ground moss, upon which they apparently feed. Its larvae live in the substrate beneath the moss. The Meropeidae, or earwig-scorpionflies, is the most primitive form of extant Mecoptera. Almost nothing is known of the adults' habits. As yet the immature stages are unknown.

Synoptic descriptions, keys, and illustrations have been prepared for the Midwestern species of Mecoptera to provide a means of identification and a review of our knowledge about this primitive and interesting group of insects. This study is now being published as a Survey bulletin and will be available soon by writing to the Chief, Illinois Natural History Survey.

Model Ecosystem in Use

The terrestrial-aquatic model ecosystem developed by Robert L. Metcalf was used this past summer to test the environmental fate of Counter, a new systemic insecticide, by entomologists Robert Metcalf and Po-Yung Lu. The insecticide, which appears promising for use in soil application for the control of corn rootworms, was furnished by the American Cyanamid Company of Princeton, N.J.

The model ecosystem is a small replica of an Illinois farm pond surrounded by a watershed planted in corn. The laboratory ecosystem, housed in an aquarium, models the farm situation with both aquatic and terrestrial sections. The water contains some of the organisms of a typical pond, such as fish, snails, mosquito larvae, algae and *Daphnia* (tiny freshwater crustaceans). On the land area, sorghum is grown in place of corn.

In testing, the insecticide Counter, radiolabeled with $^{C}14$, was injected in soil at a rate equivalent to a half pound per acre to simulate its projected use as a soil insecticide. Sorghum seeds were planted and samples of the plants removed daily for testing for the presence of $^{C}14$ or Counter in the plants.

Salt marsh caterpillars, *Estigmene acrea*, were added to the system at the end of the seventh day and they consumed the remaining plants. Then the water of the model ecosystem and all of the organisms were assayed to determine the fate of the insecticide.

Counter seemed to leach from the terrestrial phase of the ecosystem into the water relatively rapidly and the sorghum plants took up the insecticide readily. However, it was found that Counter and its oxidative metabolites do not accumulate to disturbing levels in any of the organisms in the model ecosystem. Evidence was present from radioactive $^{C}14$ in the organisms that Counter is highly biodegradable and breaks down within a few weeks. In brief, this insecticide seems promising as a replacement for chemicals previously in use in soil treatments to control corn rootworms and Counter does not seem to have the environmentally objectionable characteristics of some of the other insecticides.

Wood Duck Populations

The wood duck is one of the most beautiful Illinois ducks and an important game bird, usually being second most abundant in the bag. It is also the only duck which nests in large numbers in Illinois and wild ducklings most often seen by people in this state are wood ducks. The wood duck has unusual nesting habits in that it nests in hollows in trees, often high above the ground. The ducklings, soon after hatching, jump to the ground and are led to water by the female.

This habit of nesting in hollows has led to the development of man-made houses, suspended in trees, to increase the reproductive success of the ducks and to facilitate their study. A leader in the development of nesting houses has been Survey wildlife biologist Frank C. Bellrose, who has been studying the ecology of this bird for many years in the Quiver Creek area near Havana, Illinois.

The wood duck ducklings have been captured and web-tagged and the hens captured on the nests and banded. This marking of ducklings and hens has allowed wildlife biologists Frank Bellrose and Robert D. Crompton to ferret out certain information concerning the wood duck's population structure and ecology.

It has never been possible to tag all of the ducklings hatched in the study area; however, knowing how many have hatched makes it possible to determine the percentage which were tagged each year and this

Male wood duck in flight (photo by former wildlife biologist C. L. Scott).

is useful in sorting out other population factors. For instance, when the ratio of tagged to untagged ducklings in the total hatch in 1971 and 1972 was compared to the ratio of tagged to untagged hens found on the nests for the first time in 1972 and 1973, the ratios were found to be very similar. This indicates that most, if not all, of the first-time nesting hens were from ducklings hatched on the area in the previous year.

Hens banded on the nest give the researchers an idea of how many hens return to the area to nest again. One hen returned for seven years, a record. In 1973, fifty-five percent of the wood duck hens that nested in 1972 had returned and this is very near to the long term average.

As a result of the high water that prevailed during the 1973 wood duck brooding season, a high survival of the young was anticipated. To the contrary, the number of nesting hens declined from 187 in 1973 (49 percent unbanded) to 154 in 1974 (42 percent unbanded). If most of the unbanded hens were recruited from ducklings of the previous year, a higher mortality than expected must have occurred. This mortality must have been due to something other than increased predation or malnutrition, since the high water of 1973 increased cover and food. Perhaps chilling rains during the first day of the ducklings life produced a higher than normal mortality.

In continuing studies of the effect of environmental factors on survival of wood ducks, over a thousand ducklings were web-tagged in 1974. Knowledge of survival factors are needed in order to make predictions of populations of wood ducks more accurate.

Hog Wastes and the Silver Carp

Animal scientists have estimated that the production of wastes by domestic livestock in the United States now exceeds two billion tons annually, which is about ten times the amount produced by our human population. One method of recycling the vast stores of energy that are available in these wastes is their use to enhance fish production. It is well known that farm ponds receiving barnyard drainage sometimes produce exceptional fish populations, but may also suffer excessive growths of algae or weeds, accompanied by death of the fish population due to excessive enrichment. So far as is known, no controlled study has been made in this country of the use of animal wastes to increase fish production. In the spring of 1974 Survey biologists began preliminary studies of this problem in 10-foot diameter wading pools located at the Sam A. Parr Fisheries Research Center near Kinmundy, Illinois.

The design of the study was influenced by information gained by others. Animal scientists and agricultural engineers at the University of Illinois have developed a system wherein the wastes of confined hogs drop through a slotted floor into an aerated oxidation ditch where they are transformed by aerobic bacteria into a high-protein liquor that is reusable by the hogs. This odorless, protein-rich liquor is accepted by the hogs in lieu of water, and provides valuable supplementary protein to the diet.

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It was decided that oxidized wastes, as well as raw wastes as they would come directly from the farm hog lot, should be used in the study.

A second element of the design originated out of the centuries of experience gained by the Chinese in the culture of the so-called chinese carps, of which the silver carp is an essential member. This large cyprinid (up to 40 pounds) is an important food fish throughout Asia, in Israel, and much of eastern Europe. It is highly distinctive for its unique ability to feed almost exclusively upon plankton algae which it filters from the water with specialized gill rakers. Since such plankton algae is the most abundant food produced in waters enriched by animal wastes, it seemed essential to utilize a fish that could exploit such production.

In May each of the 21 pools was stocked with fingerling largemouth bass, bluegills and channel catfish, in addition to the silver carp. A small elevated hog house was erected to accommodate three hogs adjacent to the pools. Three pools were maintained as unenriched controls, nine were assigned to receive raw wastes at three different levels, three pools at each level, and the final nine received oxidized wastes at the same three levels. Wastes were distributed three times each week at loads equivalent to those from 20, 30 and 40 hogs per acre of surface water. The study was terminated in late September.

All pools receiving wastes developed rich algal blooms, and these caused extreme daily fluctuations in levels of dissolved oxygen. Supplementary data on water chemistry and possible accumulations of heavy metals have not yet been processed, but results in terms of fish production may be summarized as follows.

Fish production in pools receiving raw wastes was consistently higher than in those receiving oxidized wastes. In pounds per acre, average final standing crops of the combined species ranged from a high of 941 in the pools receiving the lowest level of raw waste, to a low of 463 in those receiving the highest level of oxidized wastes, compared to 474 in the control pools. The silver carp was the only species which was consistently benefited by all levels of enrichment with both kinds of waste (high, 655; low, 407; control, 243), whereas the native species were benefited to a small degree by only the lowest level of raw wastes, and suffered high mortalities and pool gains at all other levels. The silver carp proved highly efficient at converting phytoplankton into desirable fish flesh under conditions that were intolerable for bass, bluegills and catfish.

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Freeze-Dried Insects

Among the problems associated with the preservation of butterfly and moth larvae (caterpillar stage) and other soft-bodied insects is the loss of natural colors when specimens are stored in liquid preservatives. Entomologists desire to preserve an insect's lifelike appearance, and consequently, Survey entomologist Jim Appleby and some of his associates have begun freeze-drying insect larvae which they want to study.

Freeze-drying insect specimens involves several steps. Specimens are first killed by freezing. The frozen specimens are then quickly transferred to a freeze-drying machine. The chamber in which the specimens are placed is then sealed, and a partial vacuum and low water vapor pressure are maintained within it. Much of the water in the frozen specimens occurs as pure ice crystals. Under these conditions the ice crystals within the specimens change directly to water vapor. The vapor is moved from the chamber into a refrigerated unit which condenses the water vapor. The duration of the drying depends on the number and sizes of the specimens within the chamber.

When the drying is completed, the vacuum is removed, and the specimens are taken from the chamber. At a point half way down the back of each caterpillar a pin is inserted through the body. The pin supports the specimen and a label indicating the host plant and location and date of collection. Specimens dried in this manner retain their original colors and shapes for long periods when properly stored.

Few Rabid Bats in Illinois

Rabies in Illinois bats has been reported at a relatively low rate since the first two rabid Illinois bats were discovered in 1959. During the past fifteen and a half years only sixty cases of rabies in bats have been reported by the Illinois Division of Public Health Laboratories. In 1965 Survey wildlife biologist Glen Sanderson persuaded the Public Health Laboratories to save the

Freeze-dried specimen of catalpa sphinx larva. (Photo by Larry Farlow)

bats tested for rabies and send them to the Survey for identification as to age, sex, and species. Since 1965, 780 bats tested for rabies in Illinois have been submitted for identification. Of these, thirty-two (4.1 percent) have been confirmed by the Survey as rabid.

This rate does not reflect the incidence of rabies among bats, but the rate among bats tested. Usually only bats that appear to be sick or bats that have bitten someone are tested for rabies. From 1957 through 1959 the Survey tested several hundred bats collected at random from northern and southern Illinois and failed to find a single rabid bat.

The bats tested for rabies during the first seven months of 1974 illustrate the general pattern in Illinois. During this period sixty-two bats from twelve counties were tested for rabies and submitted to the Survey for identification. The bats were from Jackson County in the south to Winnebago, McHenry, and Lake counties in the north, and from Will and Cook counties on the east to Madison County on the west. However, most of the bats tested (63 percent) were from Cook County.

Seven of the twelve or thirteen species of bats found in Illinois were represented by one or more bats. The hoary bat was most often tested for rabies. Of the sixty-two bats tested, twenty-two were hoary bats (35.5 percent) and twenty-one were big brown bats (33.9 percent). These figures do not represent the actual abundance of these bats in Illinois. The hoary bat is the largest bat in Illinois, and the big brown bat is second in size. In summer both species frequent habitats in cities and towns and around farmsteads, where they are readily observed by humans. Thus, their large sizes and their habits are probably responsible for their frequent occurrence among bats tested for rabies in Illinois.

About 10 percent (six of sixty-two) of the bats tested during the first seven months of 1974 reacted positively to tests for rabies. Four of these bats were big brown bats and two were hoary bats. Four of the rabid bats were adult females, one was an adult male, and one was an immature female.

These figures, and others collected in Illinois and elsewhere, indicate that humans have little to fear from most of the bats that are commonly observed in Illinois. At the same time, individuals should avoid being bitten by bats, especially ones that cannot fly or otherwise appear to be sick.

Clams, Desirable and Undesirable

One of the world's densest populations of fingernail clams and other bottom-dwelling organisms occurs in the Keokuk Pool of the Mississippi River on the western border of Illinois. Fingernail clams serve as food for commercially valuable fish, such as channel catfish, and for diving ducks, such as the lesser scaup (or bluebill), canvasback, ringneck, and goldeneye. Because of this tremendous food resource, the Keokuk Pool receives about 20 million diving-duck days of use per year, and has been called the most important inland area for migratory diving ducks in North America.

Survey aquatic biologists R. E. Sparks and C. M. Thompson have been comparing the abundance and kinds of bottom organisms in areas of the Keokuk Pool heavily used by diving ducks and in areas little used by divers. As might be expected, fewer organisms are available in areas that receive little duck use. The next question to answer is why the clams are sparse in areas that appear similar to areas with high clam populations. Such information may help to explain why the abundant fingernail clam populations in the middle section of the Illinois River disappeared in the period 1954-1956. The number of diving ducks feeding in the Illinois River declined drastically as a result.

In cooperation with G. C. Arthur, G. J. Senn, and A. W. Fritz of the Illinois Department of Conservation, I. Smith of Hamilton, Illinois, and J. Toll and W. Watts of the U.S. Fish and Wildlife Service, clams have been transplanted from the Mississippi River to three locations in the Illinois River. The clams are kept in

specially designed plastic chambers so that their survival and growth can be checked periodically. Preliminary results show that the clams grow and reproduce in June and July, but that mortality is extremely high in August. When the test is repeated next year, chemical measurements will be made frequently in August to determine what factors are responsible for the mortality. The research on fingernail clams is supported by the Survey and the Department of Conservation.

Another clam, an alien, has appeared in Illinois waters with some unpleasant consequences. The Asiatic clam, *Corbicula manilensis,* is in the same group, Sphaeriacea, as the fingernail clam, but it grows to a larger size and has a much heavier shell. The larvae of the Asiatic clam can enter the condenser tubes of electric generating plants, and when the clams settle down and grow, the plant must be shut down to have the tubes cleaned. Survey aquatic biologist Herb Dreier is studying the life history of the Asiatic clam in Lake Sangchris, a cooling lake for a Commonwealth Edison power plant which has had condensers blocked by Asiatic clams. Meanwhile, Sparks and Thompson have found Asiatic clams at three locations on the Illinois River, including one just downstream from two large power plants.

The Asiatic clam may have other undesirable characteristics. For example, it may displace native fingernail clams. If the Asiatic clam is not as desirable a food for fish and waterfowl as the fingernail clam, because of its heavy shell and larger size, then fish and wildlife populations may decline.

It is clear that a great deal must be learned quickly about the water quality requirements and life history of both kinds of clams so that the desirable fingernail clam populations can be maintained and restored and the undesirable Asiatic clams can be controlled.

Soil-Injection Treatment for Tree Diseases

The fungicide benomyl, when injected into the soil, has been found to control some vascular wilt diseases in trees. Benomyl persists in the soil and is taken up by plant roots for several years after application. Trees accumulate benomyl or one of its derivatives in the vascular tissue of roots and stems, but the highest level of activity in benomyl-treated plants occurs in the

Survey biologists pressure sieving a bottom sample from the Keokuk Pool, Mississippi River. (Photo by R. E. Sparks)

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leaves. Therefore, reasoned Survey plant pathologist Dan Neely, soil injections of benomyl should prove more effective in controlling leaf diseases than vascular wilt diseases.

Consequently, last spring Neely began a study designed to test the effectiveness of soil injections of benomyl in controlling leaf diseases on five tree species and to compare the resulting disease control with that obtained from fungicides sprayed on the leaves. The trees and diseases that Neely tested fungicides on were anthracnose of black walnut, leaf rust of crab apple, leaf rust of hawthorn, anthracnose of sycamore, and leaf blotch of Ohio buckeye.

Some of the trees were sprayed with benomyl or one of sixteen other fungicides, benomyl was injected into the soil near other trees in a prearranged pattern and strength, and still other trees received no treatment so that the severity of the diseases on treated and untreated trees could be compared.

The effectiveness of fungicide sprays in controlling leaf diseases ranged from 0 percent to 93 percent. Of the five diseases, only leaf rust of crab apple and leaf rust of hawthorn were satisfactorily controlled by sprays. However, such control resulted from three applications of sprays. Single applications of the fungicides used on the walnut, sycamore, and Ohio buckeye reduced disease symptoms by about 50 percent, which in most cases was considered unsatisfactory.

The control of leaf diseases by soil injections of benomyl varied with the disease and the sensitivity of the causal organism to benomyl. Leaf blotch of the Ohio buckeye was almost completely controlled. No difference was noted in the degree of control of the shoot blight stage of sycamore anthracnose achieved by soil-injection and by foliar spray treatments. Soil injections of benomyl did not control hawthorn rust, crab apple rust, or walnut anthracnose.

Neely concluded that soil injection of benomyl as a method of controlling tree diseases shows real promise. Additional studies are needed, however, to determine which diseases can be controlled by using soil-injection techniques, the minimum fungicide dosage that gives satisfactory control, and the effects of benomyl on soil ecology.

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JANUARY 1975, NO. 1[illegible]

Bucks, Does, and Synchrony

The cottontail is one of Illinois's most important game animals and, as such, its biology, ecology, and management are of continued interest to Survey biologists. Among the interesting peculiarities of cottontail biology is the high correlation in time (synchrony) of the birth of early litters over large geographic areas (several counties). In Illinois, does give birth to the first litter in spring during a one- to three-day period. Wildlife biologists Charles W. Johnson and William R. Edwards have recently developed a theoretical model for the timing, synchrony, and termination of the cottontail's annual reproductive cycle.

The cottontail's reproductive organs (male and female) develop in spring under control of photoperiod, that is, increasing day length. As a result, the cottontails are physiologically ready to reproduce well in advance of the date when breeding actually occurs. Normal reproductive behavior is suppressed under conditions of unfavorable weather but is quickly released with the advent of favorable weather. Temperature appears to be the critical weather factor and cottontail breeding in recent years has coincided with the first warm spell of late winter when the minimum daily temperatures have risen above 40°F.

As breeding approaches, the dominant male cottontail defines his territory and forms a social organization with the females within this territory. When the critical time approaches, as defined by reproductive physiology and daily minimum temperatures, the does apparently provide some clue which causes the buck to initiate behavior which induces estrus, copulation, ovulation, and pregnancy. Ovulation in the does is initiated by and occurs immediately after copulation. Reproduction over sizeable geographic areas may be synchronized simply by the fact that favorable weather

Cottontail in winter in Illinois (Photo by former Survey photographer W. E. Clark).

occurs simultaneously over large areas with the passage of suitable warm fronts.

This synchronization continues through mid-June. The does are ready for breeding immediately after parturition, which takes place twenty-eight days after fertilization. Under the shortening day lengths after mid-June, the reproductive cycle begins to fail as pituitary hormones decrease, follicles fail to develop or develop at a reduced rate or in reduced numbers, and estrogen is reduced. The reproductive machinery loses steam and gradually slows to a stop in August or early September.

This theoretical model of cottontail reproductive synchronization can now be tested by making predictions of breeding dates and parturition dates. If these predictions prove successful, they can be useful in game management in the future.

Crop Pests in 1974

Extension entomologists of the University of Illinois at Urbana-Champaign and the Natural History Survey held the twenty-seventh annual Custom Spray Operators Training School at the University on January 7, 8, and 9. At this school entomologists John Wedberg, Roscoe Randall, and Tim Cooley presented a detailed report on the pests affecting crops and other human activities in Illinois during 1974. The information in this report was compiled from reports submitted by county extension advisers concerning the use and methods of application of insecticides in their counties and from information on file in the Natural History Survey.

Insect problems during 1974 were less severe than during the past few years. Corn flea beetles were very numerous in cornfields this past spring, especially in the southern and south-central part of the state. Alfalfa weevils were more numerous in the central section, as well as in the southern section of the state. Fall armyworms were very common in late-planted cornfields in the southern half of the state. Corn rootworm damage was more common during 1974 than in 1973, primarily because of adverse weather and soil conditions that rendered organic phosphate and carbamate insecticides less effective. The most common pests of garden, yard, and home were aphids, bagworms, and vegetable insects.

County extension advisers each responded to an average of 610 contacts pertaining to insect problems. Of these, 274 were about agricultural pests and 336 concerned home, lawn, and garden insect problems.

An estimated 6,991,700 acres of field crops were treated with insecticides in Illinois during 1974 with a savings from crop loss to farmers of about $39,800,000 over and above treatment costs. Control of insects in corn accounted for 70 percent of the estimated crop savings from the use of insecticides.

Corn rootworm damage in 1975 is expected to be most likely north of a line from Collinsville to Paris in fields planted to corn for two or more consecutive years. A potential for moderate to severe damage from these pests exists, especially in central and northwestern Illinois. Farmers who have experienced rootworm damage in past years and who grow continuous corn should use a rootworm soil insecticide at planting. Research indicates that corn producers ought to make two corn rootworm counts, on August 5 and on August 25 in 1975. If these show an average of one or more rootworm beetles per ear tip, a rootworm insecticide should be applied if the field is replanted to corn in the following year.

As in past years, Illinois farmers will be able to keep one step ahead of insect pests, at least in part due to the dedicated surveillance, research, and advice afforded by our extension entomologists and county extension advisers.

Thrips and Soybeans

The majority of animals (pests and otherwise) that are authentically identified for the people of Illinois are named or verified by the staff of the Faunistic Section of the Survey. Some 20,000 species of insects alone, each having larval stages of distinct appearance, are present in our state. To be able to determine and separate one species from another from among these 40,000 or so forms (adults and

larvae), much study and a well-represented reference collection are necessary.

Now that soybeans have become one of Illinois's most important crops, studies of soybean insect pests have been given top priority. One of the groups associated with soybeans is the tiny leaf-feeding thrip, one species of which transmits a virus disease and several of which are beneficial predators on mites and insects. Unfortunately, when the farmer observes damaged soybean leaves in the field, the adult thrips fly off, leaving only the wingless larvae to be sent to the Survey for identification and control suggestions. Until now, keys, identification aids, and a reference collection of the larvae have not been available. To remedy this situation, Thomas C. Vance, a graduate student at the University of Illinois jointly supported by the Faunistic Section and the Economic Entomology Section, has completed an investigation of the larvae of soybeans, as well as related larvae of the saw-bearing thrips (Terebrantia) for Illinois. His work has been recently published as a Survey bulletin entitled "Larvae of the Sericothripini (Thysanoptera: Thripidae), with reference to other larvae of the Terebrantia of Illinois," and is available free by request from the Chief of the Illinois Natural History Survey, Urbana, Illinois 61801.

Larval thrips on a soybean leaf (Photo by Survey photographer Larry Farlow).

Mr. Vance's work is highly technical, with illustrated descriptions of the minute structures that characterize each species in the larval form. A good research microscope is needed to observe the species treated in this bulletin, and training in entomology is a prerequisite to take proper advantage of the keys and analytical descriptions presented. A section is devoted to the life history of the most common thrips on soybeans as an example of the complicated biology of these insects. This study has made possible the determination to species of these minute, but sometimes destructive, creatures by specialized entomologists who can then pass on their findings to the general public and farmers for money-saving crop protection and increased yields.

Turfgrass and Aquatic Herbicides

There are approximately 800 golf courses in the state of Illinois. Golf courses, as many golfers have found, have bodies of water that serve as water hazards. Most golf course ponds are used as a source of irrigation water for the greens and fairways. These bodies of water also have become infested with aquatic plants and filamentous algae which interfere with the use of the water for irrigation.

For several years, Survey aquatic biologist Robert C. Hiltibran has been receiving requests from golf course managers for control methods for the various aquatic plant problems in their golf course ponds. Available aquatic herbicides for the control of common aquatic plant nuisances could be suggested, but very little information was available on effects of these herbicides on turfgrasses. Therefore, Survey biologists Hiltibran and Linda Klippert, in cooperation with A. L. Turgeon, Department of Horticulture, University of Illinois, initi-

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ated an investigation to determine the effects of aquatic herbicides on turfgrass.

One inch of irrigation water, containing the suggested rates of aquatic herbicides necessary for the control of the various aquatic plant problems, was applied to four-by-six-foot areas in triplicate. Nine aquatic herbicides were applied to seaside creeping bentgrass in three applications during the summer of 1973 resulting in slight damage to the bentgrass in some of the areas treated with diquat and dichlobenil. There was no damage to the bentgrass in any of the areas treated with the other aquatic herbicides.

This investigation was expanded in 1974 with the assistance of Kathy Ewing, Linda Klippert, and Gary Burtle, and sixteen aquatic herbicides were applied to test areas of penncross creeping bentgrass on several dates. The effects of the aquatic herbicides on the penncross creeping bentgrass were estimated using a visual rating system, color, and color infrared photography.

The following aquatic herbicides did not affect the penncross creeping bentgrass in any of the application sequences: dimethylamine salt of 2,4-D, copper sulfate or copper sulfate-triethanolamine complex, diuron, fenac, N, N-dimethyalkylamine salt of endothall, and the mono- and di-dimethyltridecylamine oxides of endothall.

Simazine, the butoxyethanol ester of 2,4-D, the combination of potassium silvex and potassium endothall, diquat-copper triethanolamine complex affected the turfgrass in a six-weekly application sequence only, but the damage did not become evident until after three or four weekly applications.

Dichlobenil, diquat, and the butoxyethanol ester of silvex caused damage to the bentgrass in all application sequences except the single application in late May. The turfgrass appeared to recover in the dichlobenil test areas in the applications on May 29 to June 4 and July 29-30 and the weekly applications on July 29-30 and August 7-8. A closer inspection indicated that a species shift of grasses had occurred. Since the dichlobenil applications in late May did not have any effect on the turfgrass, but the damage became more severe in late summer, three areas were treated in late August with one half the rate applied to the other dichlobenil areas. Damage occurred to the bentgrass in these areas, indicating that the bentgrass was more susceptible to dichlobenil in late summer.

With these data available, golf course operators will now be able to obtain advice for the control of their aquatic plant problems without causing damage to the turfgrass.

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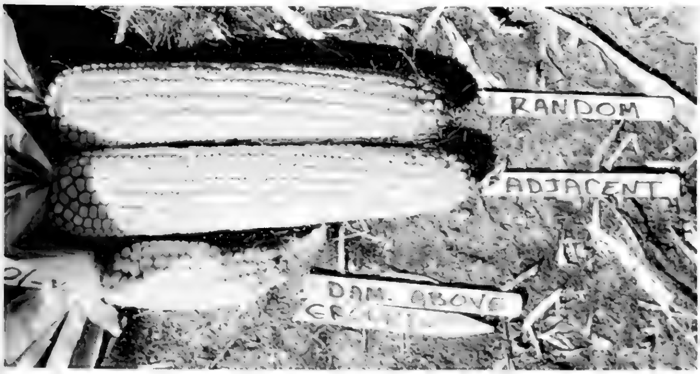
Black Cutworm Damage to Corn

In June 1973 a black-cutworm-damage study in corn was initiated in one field in Shelby County and expanded the following year to include five fields in two counties, three in Shelby and two in St. Clair. The purpose of the study was to obtain accurate information concerning yield loss due to black cutworm damage so that entomologists could give accurate control recommendations to corn growers.

Survey entomologists knew that cutworm moths fly into corn fields beginning in May and deposit eggs on ground debris. The eggs hatch and the small larvae begin crawling along the ground searching for food, encountering new corn plants along the way. During the early stages of the life cycle, the larvae generally feed only on the leaves, but beginning with the half-grown, or third instar, stage the true "cutworm" comes into being as the larvae begin tunnelling into or chewing off plants near ground level.

The damage study began at this point, during the last week of May and the first week of June, when cutworm damage was obvious and when 4 to 10 percent of the plants were found to be damaged. Each damaged plant was marked with a wooden stake and given an individual number keyed to a field notebook in which data were recorded concerning date of damage, whether the plant was cut above or below ground, plant height, field history, and other pertinent information. These study plots were examined for two weeks, through mid-June, and then left alone until harvest time in the fall.

During harvest, ears (if any) from all the damaged plants were taken and recorded as "damaged." In addition, for each damaged plant an ear from the plant next to the damaged plant was taken and recorded as "adjacent." Another ear was taken from a plant that had normal spacing and plants on either side of it and was recorded as "random." This corn was then shelled and weighed by individual ears and corrected to 15.5 percent moisture content.



Ears of corn from a field in which black cutworms were active. The bottom ear is from a plant that was damaged above the ground, the middle ear is from a plant that was adjacent to a damaged plant, and the ear at the top is from an undamaged plant chosen at random. (Photo by Tim Cooley)

When computing the yield data for this study, the entomologists assumed that the yield from the random ears was the yield that would have resulted if no plants had been damaged by cutworms. It was found that the average damaged plant produced only 15 percent of the yield of the random plant. The adjacent plant picked up an additional 10 percent yield compared to the yield of the random plant due to the lessened competition by the damaged plant. The final figure showed that for every 1 percent of his corn plants damaged by cutworms during May and June the farmer can expect a yield loss of 0.7 percent. In addition, this study showed that only 36 percent of the damaged plants recovered sufficiently to produce any ears at all, and the ears on these plants were generally substandard when they did occur.

Due to the unexpectedly low recovery potential of black-cutworm-damaged plants and the resulting high yield loss, Survey entomologists hope that farmers will take special care in determining the extent of damage in newly emerged corn in the future.

Thrush Has Compass, Will Travel

Returning to the birthplace to breed is a characteristic of all migratory birds. Survey wildlife biologist William Cochran over a period of years has developed many tiny radio transmitters with which to follow the movements and migrations of wild birds and mammals. A transmitter is attached to an animal, and the signal that it emits is followed by means of a receiver mounted in a stationary location or in a truck or airplane.

Cochran's studies of the migration of Swainson's thrush and other thrushes have resulted in some interesting findings. He has found, for example, that notable lateral drifting caused by winds is usual during their migrations. The drift amounts to a few hundred miles to the right or left over a course of 2,000-3,000 miles. Although this relatively small drift may seem remarkable in view of the great distances, strong winds, and tiny birds involved, it represents far too great a potential error to allow these birds to return to their birthplaces year after year.

Cochran has found that thrushes apparently have the ability to follow a compass heading on their migrations and that this heading is determined by a response to the earth's magnetic field. A thrush can use the horizontal component of the earth's magnetic field as a compass cue with an accuracy that is better, and perhaps much better, than one or two degrees. However, an error of even one-half of one degree represents an error on the ground of about fifty miles. How, then, does the thrush find its way to the nesting area?

Cochran's theory, which his research appears to be confirming, is that thrushes respond not only to the horizontal component of the earth's magnetic field, but also to its inclination (or dip) angle. If this is so, the thrush's generally northward migration would be ended at the magnetic latitude (inclination angle) of its birthplace. The bird would then abruptly change direction. It would fly about at right angles to the horizontal component of the earth's magnetic field and fly along the isoclinic line that passes through the thrush's breeding site. Thus, it would correct the wind-drift error in its northward flight and eventually arrive at its birthplace.

Most thrushes passing through Illinois are still far south of their breeding areas and would not be expected to turn from the northerly direction of their migration. However, two birds to which Cochran had attached transmitters have made such turns.

In 1966 one bird flew north until it neared Hoopeston, where it turned eastward. The 71.2-degree isoclinic line, at which this bird turned, intersects the breeding area of this species in the Appalachians of southern Pennsylvania. After following this line for about fifty miles, the bird landed, and its transmitter fell off the next day.

In May 1974 another bird turned from its northward migration route. Cochran followed it from Champaign roughly north-northwest to Clinton, Iowa, where it

A tiny radio transmitter, weighing less than one-tenth of an ounce, attached to the back of a *Hylocichla* thrush. (Photo by former Survey photographer Wilmer Zehr)

changed direction to approximately west. It flew west for at least seventy miles, at which point the tracking airplane was forced down by storms. The 71.9-degree isoclinic line which passes through Clinton, Iowa, intersects this thrush's breeding area in western Montana.

These observations support Cochran's theory, but he will have to track many more birds exhibiting such behavior, and at least one bird all the way to its nest site, before he will be convinced that he has explained how thrushes find their way to their nesting areas.

High Water and Good Fishing?

Fluctuating water levels in flood control reservoirs result in alternating expansion and shrinkage of stream and reservoir habitats for fish. Into Lake Shelbyville, for example, flow 14 small, fish-inhabited streams exclusive of the Kaskaskia and Okaw rivers. As the reservoir water level increases in the spring, the waters of these streams are backed up and their adjacent floodplains are inundated. Thus, the waters of a stream become more like those of a reservoir, and the habitat available to the fish population of the reservoir is greatly increased. In the fall, water levels are reduced, and the aquatic habitat of the floodplain is eliminated. Survey aquatic biologists Ted Storck and Don Dufford are investigating the responses of fish populations to these fluctuating water levels.

Whitley Creek, a small tributary of Lake Shelbyville, was chosen for the study. In 1974 heavy spring rains resulted in the backing up, or impoundment, of a large portion of the waters of this stream, which reverted to stream habitat in the late summer as the reservoir water level dropped. Although the investigation is not complete, some preliminary conclusions can be presented now.

Typical stream-inhabiting fish species disappeared from the impounded portions of the stream. It is not known if these species moved upstream in advance of rising water levels or remained where they were to be consumed by predator fish from the reservoir. However, all stream species collected in Whitley Creek in 1971 were

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still present in 1974, and there were no great changes in relative abundance.

Small numbers of stream species returned, within a few weeks, to the previously impounded sections of stream when they reverted to stream habitat, but the return of normal numbers of stream species to these areas was much slower.

Reservoir species invaded Whitley Creek in the spring both before and during the impoundment process. Notably, large numbers of largemouth bass and a few gizzard shad moved several miles into Whitley Creek and its tributaries in April and May. These movements occurred before the impoundment of large sections of Whitley Creek. In addition, gizzard shad, carp, bluegill, crappie, drum, bowfin, and bigmouth buffalo quickly invaded the expanding habitat created by the impoundment of Whitley Creek. Within two weeks of the creek's becoming impounded, large numbers of adult gizzard shad and carp and lesser numbers of other reservoir species moved into flooded fields along the stream. These areas were subsequently used by these species for spawning and nursery grounds. Young gizzard shad reached phenomenal densities in these areas in 1974. Other species produced smaller but substantial broods.

As water levels decreased in August and nursery habitat was obliterated, both adult and young-of-the-year reservoir species moved downstream. Adults moved quickly, and few, if any, reservoir species remained when the habitat reverted to stream conditions. Young-of-the-year fish were slower to respond to the shrinking habitat, and temporary concentrations of these young fish occurred.

It is difficult to assess the importance of the contribution to reservoir populations of young fish produced in tributary streams. The numbers of fish involved have not been determined, nor is it clear what constitutes a significant number. However, the impounding and flooding of tributary stream floodplains appears similar ~~to~~ the initial impoundment of a reservoir. It is during this stage of reservoir development, when vegetation is flooded and nutrients are being released into the water, that fish growth is greatest and sport fishing is at its best. After a few years fishing success begins to decline. The periodic flooding of tributary stream floodplains may serve to prolong the years of good fishing. Storck and Dufford have demonstrated only that reservoir species do exploit these areas and that the potential for contributing to reservoir fish populations is present.

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MARCH 1975 NO. 14[illegible]

Counter, Corn Rootworms, and Pheasants

The era of controlling corn rootworm infestations with persistent chlorinated hydrocarbon compounds is waning, and hopefully, from the standpoint of environmental contamination, will soon be history. These chemical insecticides are being replaced principally by the highly toxic, but short-lived, organic phosphate insecticides. One of the promising new organophosphate compounds for controlling corn rootworms, called COUNTER 15G Soil Insecticide, has been developed by American Cyanamid Company. This granular insecticide, which has a half-life of about 14 days, is applied at an agricultural rate of one pound of technical material per acre in a 7-inch band over the corn row; it is pressed, but not incorporated, into the upper soil surface.

What impact might field applications of COUNTER be expected to exert on wildlife populations? To provide some answers to this question, Survey wildlife specialist Ronald F. Labisky exposed confined hen pheasants to simulated field applications of COUNTER Soil Insecticide at rates of both one and five pounds of technical material per acre for 55 days during July and August 1973. Hen pheasants, because of the high energy drains associated with egg-laying and molt, are in their poorest physiological condition during this late summer period, and, therefore, are unusually susceptible to any extrinsic stress — such as a toxic chemical — that could potentially accelerate mortality.

Tray of soil, treated with COUNTER, after being placed in pen with pheasants. The dusting activity by the birds insures dermal contact with the insecticide. (Photo by former Survey photographer, Wilmer Zehr)

The results of this study, which will be published in the *Journal of Wildlife Management* in 1975, were favorable for both pheasants and COUNTER. First, none of the 15 hens (five pens of three hens each) exposed on July 19, 1973, to dosage rates of either one or five pounds of technical COUNTER per acre died or exhibited symptoms of organophosphate poisoning during the first 22 days of experimentation; similarly, there were no losses among the 15 hens in the nontreatment control group. Second, no residues of COUNTER or its metabolites were found in any tissue or organ from a sample of five hens sacrificed from each of the 1- and 5-pound COUNTER groups after 22 days of exposure to the insecticide. Third, body weights, or changes in body weight, did not differ significantly among the control, 1-pound COUNTER, and 5-pound COUNTER groups of hens during the first 22 days of the experiment. And, finally, no mortality had occurred by November 6,

1973, or 106 days after the onset of the experiment, among the ten hens remaining in each of the COUNTER treatment groups or in the nontreatment control group. These findings suggested that field applications of COUNTER in spring at the recommended dosage rate of one pound of technical material per acre would not be a serious depressant to resident populations of pheasants. Currently, the short-lived organophosphate insecticides appear to be much better friends to both wildlife and environment than were their predecessors, the persistent chlorinated hydrocarbons.

Aquatic Plants and Diquat

The aquatic plants, sago pondweed, *Potamogeton pectinatus,* and curlyleaf pondweed, *P. crispus,* are susceptible to the aquatic herbicide diquat, where as American pondweed, *P. nodosus,* and cabomba, *Cabomba caroliniana,* are not susceptible to diquat.

In order to better understand this phenomena, aquatic biologists Robert C. Hiltibran and Gary Burtle have been investigating the uptake and translocation of diquat labeled with radioactive carbon (C^{14}) by these aquatic plants.

These studies were carried out by exposing either the roots or the shoots of the aquatic plants to labeled diquat in separate compartments. To estimate the uptake of the labeled diquat and to determine if there was a good seal between the two compartments, the radioactivity content of the water was estimated using liquid scintillation techniques prior to and after the exposure period. To estimate if translocation has occurred, the aquatic plants after exposure were freeze-dried, mounted on paper, and placed on x-ray film. After suitable periods of exposure, the position of the radioactive material could be determined.

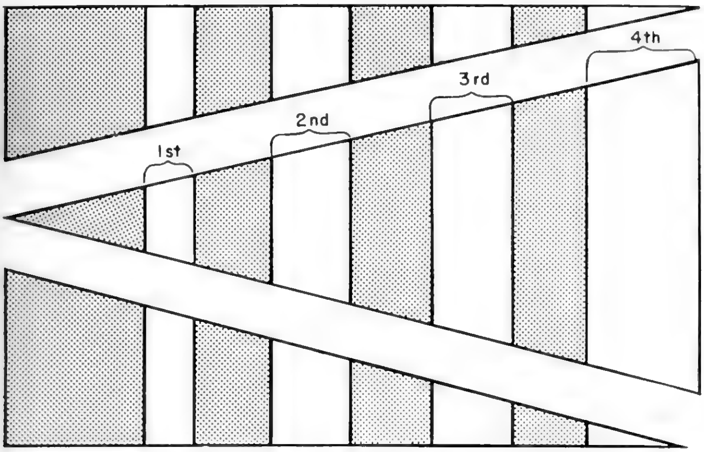
The data indicated that all the aquatic plants susceptible to diquat take up more of the herbicide than do the non-susceptible aquatic plants. The exposure times utilized in this study were for 48 hours of exposure. Under laboratory conditions diquat can remain in the water for this period of time, but other data indicate that diquat breaks down and disappears rapidly under field conditions, perhaps in less than 48 hours. The short exposure time under field conditions appears to be sufficient for the susceptible aquatic plants to take up lethal quantities of diquat, whereas the non-susceptible aquatic plants apparently do not take up lethal quantities of the herbicide before it disappears from the water. Further, American pondweed seemed to have either metabolized the diquat or translocated the labeled diquat. Further studies are necessary to determine which may have been done.

A New Research Tool

One of the continuing problems associated with most research projects is developing new and/or modifying old methods which will save time, yet maintain or improve the quality of the research. Survey entomologists D. P. Bartell and S. J. Roberts, members of the alfalfa pest management team, recently developed a new technique that not only has applications in their work with the alfalfa weevil, *Hypera postica,* but also can be adapted to a variety of other insects.

Intensive sampling programs being conducted in several alfalfa fields in Washington County generate a large number of samples which often contain several hundred larvae (feeding stage) of the alfalfa weevil per sample. Once the larvae have been extracted from the plant material, the most difficult and time-consuming problem is to determine the age (1st through 4th stage) of each larva. Age classifications are essential in order to monitor the maturity of the population at a given time and throughout the season.

In the past, alfalfa weevil researchers have used differences in head capsule size (width) as the most reliable indicator to separate age groups; however, the methods used to make these classifications ranged from a visual estimate (often in error) to a tedious microscope measurement (precise, but time-consuming) of each larval head capsule. The new technique described and



Schematic diagram of head capsule caliper. (Drawing by Lloyd LeMere, Survey artist, and photographed by Larry Farlow, Survey photographer)

illustrated herein — referred to as a head capsule caliper — bridges the gap between these two extremes.

An original drawing of the head capsule caliper was prepared 100 times larger than the actual dimensions reported for head capsules of alfalfa weevil larvae. This drawing was then photographed on litho-film with a graphic arts camera. The caliper dimensions were precisely matched to actual head capsule ranges by a series of photographic reductions. Contact prints were printed on high contrast film and enclosed in thin glass photographic slide mounts to prevent damage to the prints from excessive handling and to eliminate the need for frequent replacement.

The head capsule caliper is used directly on the stage of a binocular microscope. Larvae from a given sample are removed from the alcohol with forceps by grasping each larva behind the head. The larva is then placed on and moved through the triangular area of the caliper until the head capsule fits within the range of one of the stages.

The head capsule caliper offers a means by which large numbers of larvae can be separated into age groups rapidly and accurately. In addition, calipers have been adapted for the corn earworm, *Heliothis zea;* the northern corn rootworm, *Diabrotica longicornis;* the bean leaf beetle, *Cerotoma trifurcata;* and the spruce beetle, *Dendroctonus obesus.*

Predicting Water Quality

Biologists have used several methods to analyze the effects of man's activities on aquatic environments. These methods have included measuring selected physical and chemical indices as well as a variety of biological measurements. Demands have increased from governmental agencies for accurate identifications of aquatic organisms for use in environmental impact statements. The lack of knowledge about water tolerances of larger aquatic invertebrates and lack of identification aids for immature insects have hampered study in this field.

In a recent article in the Journal of the Water Pollution Control Federation, Vincent H. Resh (Ball State University, Muncie, Indiana) and Survey entomologist John D. Unzicker have demonstrated how water quality tolerances can be developed for a group of aquatic insects, the caddisflies. They chose the caddisfly genus *Athripsodes* for several reasons: it has a large number of species (approximately 40) with varied life histories; they are widely distributed and frequently collected in aquatic surveys; the larval and adult associations have been made for eastern North American species and identification keys can be constructed for the immature stages; and the genus possesses species which are intolerant and species which are tolerant to pollution. By using standard

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water chemistry techniques, a knowledge of immature and adult taxonomy, literature reviews, examination of biological collections (past and present), and a re-examination of previous collecting sites, they have shown how species dominance in the genus shifts with changes in the water quality of several midwestern streams and one lake.

Water quality in the Rock River in northern Illinois has deteriorated over the last 50 years due to urbanization and industrialization causing a shift in the dominant species of *Athripsodes* from *menteius* in the 1920's to *transversus* in the 1970's. In contrast to the Rock River, the Apple River in the northwestern part of the state has remained essentially unchanged since the 1930's and still supports a population of *A. flavus*. Similar faunal changes have been demonstrated in northern streams such as the St. Lawrence and Niagara rivers and Lake Erie.

A valuable source of baseline data for a particular area is specimens collected during earlier studies and deposited in permanent scientific collections such as those at the Illinois Natural History Survey. Rarely are lists of animals and plants published for precise sites that may be proposed for nuclear reactor plants or other major construction projects. Extensive collections such as those maintained by the Survey since 1858 greatly exceed the published records of an area and can provide data for such environmental studies. If water chemistry is collected concurrently with aquatic insects, annotations of water quality tolerances can be developed at the species level.

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Gladiolus Virus Up-Date

Gladiolus virus disease research at the Natural History Survey has focused on the most important disease, white break, which is caused by the cucumber mosaic virus. This virus causes diseases in many important crops and is known to be able to infect over 300 plant species. Of additional importance is the fact that this virus is transmitted from one plant to another by over 60 species of aphids. In gladioli the disease has been reported to occur in up to 100 percent of the plants of some varieties. However, there was much confusion on this and related matters when Survey plant pathologists Walter Hartstirn and J. L. Forsberg started their research toward a better understanding of this disease and how to control it.

Among the first factors investigated were where and when this disease is most likely to occur. Sixty-seven gladiolus varieties were evaluated, and great variations in susceptibility were found. Thus, the first step toward the control of white break was located. By using less susceptible varieties, it is possible to avoid much of this disease. Further research indicated that the time of planting was also extremely important. One variety planted at the beginning of May in central Illinois encountered much less white break disease than it did if planted in late June. Early planting became another step the commercial grower or home gardener could use to avoid this disease.

Questions arose about how much disease is carried over from one year to the next. Some reports indicated that the carry-over didn't always occur. In the research on this problem it was found that once a plant is infected, the succeeding generations of corms (commonly called bulbs) always carry the disease. However, not all varieties show disease symptoms in every generation. This fact explained why some people reported the "recovery" of their plants. The fact that plants carry the disease from generation to generation led to another step toward the control of white break.

White break symptoms show as white streaks and splotches on the normally dark red King David gladiolus. (Photo by J. L. Forsberg)

This step is the removal and destruction of all infected plants as soon as they are noticed. This action prevents aphids from feeding on diseased plants and carrying the disease to healthy plants.

The scientists then asked whether the cormels (bulblets) from an infected plant carries the disease. Research indicated that most, but not all, of the cormels produce infected plants if the parent plant had white break. Cormels from infected plants, therefore, should be destroyed.

Other research was designed to determine if white break could be transmitted by the pollen carried by bees. It was found that not only is there no transmission by this method, but not even the seeds formed on diseased plants carry the disease. This fact was considered important for those who hybridize gladioli to develop new varieties and use white or yellow varieties. White and yellow varieties sometimes are infected with white break but show no symptoms.

Many other facts about the disease, such as its symptom variations and its relationships with other diseases, were learned along the way. These should prove of value to future research that may be necessary on gladioli or other plants.

Squirrel Hunting in Illinois

Game populations should be managed with seasons and bag limits that protect the game resource, but most of our hunting regulations are based on tradition, not biology. However, Survey wildlife biologists Charles M. Nixon and Stephen P. Havera find no evidence that Illinois squirrels are being overharvested under the present squirrel season and bag limit. Hunters like to hunt squirrels during the seed-maturing stage of oaks and hickories in late summer when squirrels often are still breeding, pregnant, or nursing young. However, the loss of nestling or fetal young, when breeding females are shot, is not a serious problem in Illinois. Such losses of nestlings represent less than 10 percent of the fall squirrel population. Many biologists believe that squirrel populations are underharvested, at least in extensive forestland, and could support additional hunting pressure. Thus, conservation agencies try to choose opening dates for squirrel hunting that are neither so early as to waste large numbers of young in the nest, nor so late as to jeopardize hunting success.

The obvious solution is to delay opening the squirrel season until the young are weaned, usually in late September or early October. But such a delay would eliminate hunting recreation during the summer and early fall when sportsmen have nothing else to hunt. A responsibility of wildlife managers is not only to provide seasons and bag limits that protect the game resource, but also to provide sportsmen with the maximum opportunity to pursue their sport.

The present season framework is a suitable compromise. Hunter interest is highest from mid-August until mid-October. The present seasons give the southern Illinois hunter 8 to 9 weeks and the northern hunter 6 weeks of prime hunting time.

The small, scattered tracts of forest in northern Illinois are potentially vulnerable to overshooting. The opening on August 1 in the south zone places the most sustained hunting pressure in the more extensive forests of southern Illinois, where squirrel populations are least likely to be overshot.

Hunters are generally satisfied with the present opening dates in both zones. They are not so certain about an extension of the season past November 15. Nixon and Havera recommend that the squirrel season end no later than November 15. It makes little sense to extend the season into a time span that most hunters will not use and when a majority of hunters oppose an extension. In addition, squirrel breeding begins in the south zone before December 15, and a season extending into the breeding season would be unwise.

Hunters are generally satisfied with the present bag limit although a few prefer a reduction to a limit of four. Nearly all hunters oppose an increase to six squirrels. Nixon and Havera believe that far better

Survey wildlife biologists have found no evidence that Illinois squirrel populations are being overharvested under the present season and bag limit. (Photo by George W. Bennett)

estimates of how many squirrels are shot each year in Illinois are needed. They do not believe that Illinois squirrel hunters annually bag nearly one squirrel per 1.5 acres of forest; no other state approaches such a squirrel harvest. Thus, if we are to manage the squirrel crop more effectively, we must improve the estimates of the annual squirrel harvest.

In summary, the Survey biologists make these recommendations on the squirrel season and limit: south zone — August 1-November 15; north zone — September 1-November 15; bag limit — five squirrels.

Model-Ecosystem Pesticide Tests

Modern agricultural practices involving superior plant varieties, improved cropping methods, heavy applications of fertilizers, and strong reliance on agricultural chemicals have been largely responsible for the tremendous agricultural productivity of Illinois. Such innovations have resulted in increases in the average corn yield in Illinois from 30 bushels per acre in 1920 to 105 bushels per acre in 1973.

The use of pesticides has increased phenomenally over the years, and in Illinois more total acreage is treated with pesticides (more than 14 million acres) than is treated in any other state. Such heavy use of pesticides and the rapid introduction of new pesticides require careful, continuing surveillance of the effects of these chemicals in the environment.

A year ago the *Illinois Natural History Survey Reports* told about economic entomologist James Sanborn's test of the fungicide Captan in the terrestrial-aquatic model ecosystem developed by University of Illinois Professor Robert L. Metcalf. This laboratory ecosystem, housed in a 20-gallon aquarium, is a small-scale model of an Illinois farm pond surrounded by a watershed planted in corn. The model had both water and terrestrial portions. In the water portion are such typical pond organisms as a fish, snails, mosquito larvae, algae, and *Daphnia* (tiny freshwater crustaceans). On the sand portion, sorghum is grown and each pesticide tested in this model ecosystem is applied to the plants. After a specified number of days, the animals, plants, and water of the ecosystem are examined for pesticide residues to determine whether the pesticide is ingested and broken down or accumulated by the various links in the food chain and whether it persists in the environment.

Recently Sanborn has published a report on 17 organic pesticides and five industrial chemicals that he tested in the

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terrestrial-aquatic model ecosystem. Several types of pesticides were represented in the tests, since one or more insecticides, herbicides, miticides, and plasticizers, and other pesticides were tested. These model ecosystem tests generate data which can be compared with data from the field to provide the background information needed to assess the potential environmental impact of new pesticides before they are recommended or rejected for general use.

In general, Sanborn found that most of the chemicals tested, with the exception of the persistent soil insecticide dieldrin, underwent extensive degradation. Dieldrin was exceptional in that more than 96 percent of the radioactive materials isolated from the organisms of the model ecosystem was unchanged dieldrin, clearly showing the extreme inability of this chlorinated hydrocarbon to undergo biological and chemical modification.

Sanborn's new publication, *The Fate of Select Pesticides in the Aquatic Environment*, was published by the U.S. Environmental Protection Agency and is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

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Spring Goose Migration

Aldo Leopold once wrote, "What a dull world if we knew all about geese!" The mystery surrounding the beautiful V's of Canada geese against the sky as they migrate south in the fall or north in the spring is encapsulated in Leopold's words.

The Mississippi Valley goose population winters in southern Illinois and adjoining states and nests in northern Ontario. This population has grown from a post-hunting season level of 22,000 in 1945, to about 300,000 today. The fall migration of these geese to their wintering areas is well known and studied, but the spring migration has received less public attention. Survey wildlife specialist Harold C. Hanson together with Richard A. Hunt, research biologist with the Wisconsin Department of Natural Resources, has recently published an article in *Wisconsin Conservation Bulletin* describing the feeding behavior of Canada geese in Wisconsin during their spring migration northwards.

About three-fourths of the spring migration of geese (amounting to nearly 400,000 geese) passes through Wisconsin on the way to their northern breeding grounds. This migration, though lacking the hunting pressure of the fall migration, is not the leisurely, carefree flight home it first appears. Instead, it is a very critical time of energy storage that may affect the bird's

Canada geese in flight over winter grounds in southern Illinois. (Photo by Harold C. Hanson)

reproductive success and possibly survival of weaker immature geese. It is now apparent that Wisconsin's role as a primary host is more significant during the spring migration than its role in the fall when so much management has been directed toward affording food and a sanctuary area.

In the spring the Canada geese stop in fields in Wisconsin to feed on waste corn in the thousands of acres of cornland in the dairy areas of the southeast portion of the state. The geese also feed on highly nutritious green shoots of grasses and other plants in these fields. However, careful observation revealed that the geese receive surprisingly large quantities of nutrition from manure which is spread over the fields from dairy barns. The cattle, having fed on ensilage containing whole grains of corn, pass much corn undigested. The geese glean this corn from the manure spread over the land and also may obtain significant amounts of vitamin B_{12} produced by the microflora in the cow's gut and also present in the manure.

From a management standpoint, the welfare of the geese in spring is almost cost free, thanks to the farmers on whose land the birds feed. While some crop damage does occur each year, Wisconsin has a law which pays farmers for such losses. Unlike the shrinking wetland habitat for migrating ducks, the wealth of food available to migrant geese in the southeastern quadrant of Wisconsin in spring seems secure unless the dairy economy declines precipitously.

Corn Rootworms and Sweet Corn

Three species of rootworms — the northern, southern, and western corn rootworm — attack sweet corn in Illinois. The southern corn rootworm, though present throughout the state, rarely is a serious problem in central and northern Illinois. The northern corn rootworm (*Diabrotica longicornis*) and the western corn rootworm (*Diabrotica virgifera*) are both serious pests of sweet corn in the northern two-thirds of the state.

The northern corn rootworm and the western corn rootworm are small beetles in the adult stage which can be found feeding on the pollen, silks, and leaves of corn from mid-July until the first frosts in the fall. The females lay eggs in the soil chiefly from August until mid-September. The eggs remain in the soil over winter, affecting corn planted in the following year. The larvae feed on the roots of the corn, weakening the roots enough to cause lodging on windy days and decreasing the yield of affected plants.

Survey entomologists W. H. Luckmann, J. T. Shaw, D. E. Kuhlman, R. Randell, and C. D. LeSar have recently published Survey Circular 54 entitled, "Corn Rootworm Pest Management in Canning Sweet Corn." In this circular several factors affecting the abundance of corn rootworms in sweet corn fields are described and a management program is outlined for sweet corn in fields that were planted to sweet corn the previous year. This program is not intended for fields of sweet corn planted where field corn was grown the previous year, as some of the factors affecting rootworm oviposition and consequent populations are quite different.

Some of the factors affecting corn rootworm populations in a field of sweet corn are as follows: Fields harvested before August 8 will attract few egg-laying rootworm adults, since the fields are harvested before intensive oviposition begins, and little or no damage need be expected the next year. Fields of sweet corn are not attractive to egg-laying adults after they have been mechanically harvested (no standing stalks in the field following harvest). Aerial or ground sprays of carbaryl insecticides applied for control of the European corn borer and the corn earworm are very toxic to adult rootworms, and egg-laying adults are eliminated from sprayed fields once the spray program is begun.

A copy of Circular 54 can be obtained by anyone interested in the full details of this management system by request from the Chief, Illinois Natural History Survey, Urbana.

Seventeen-year cicadas on tree trunk. (Photo by former Survey Photographer Wilmer Zehr)

Illinois' Periodical Cicadas

Over the past ten years, Survey entomologist Lewis J. Stannard, with the help of the staff of the Illinois Natural History Survey, Farm Advisers, and many private citizens, has investigated the ranges and occurrences of the broods of periodical cicadas in Illinois. From the resulting data forecasts of the emergence of these insects can be made with good accuracy for the benefit of orchardists, nurserymen and anyone concerned with protecting choice trees from damage to twigs.

Periodical cicadas are among the world's longest lived insects, some living 13 years and some 17 years, with most of this time spent underground as nymphs feeding on tree roots. The adults emerge in late May and early June at the end of their 13 or 17 year development period. During the short time of their life above ground, periodical cicadas congregate in the hundreds of thousands, sing in deafening choruses and mate. The females slit twigs and lay their eggs in these slits, an action which often causes girdling and destruction of the twigs. When hatched, the young nymphal cicadas drop to the ground and dig in to feed on tree roots to begin a new generation of 13 or 17 years duration. Ordinarily those with 13-year life cycles are southern broods and those with 17-year cycles are northern broods, the dividing line being roughly from north of Quincy to north of Danville. Only five separate broods of periodical cicadas are found in Illinois, three with a 17-year life cycle and two with a 13-year life cycle. Each brood is generally separated from other broods with few woods having more than one of the five broods. None occur in sandy soils, although some fairly small cicadas, not periodical species, do occur in some sandy areas. Dog-day cicadas are present every year and appear beginning early July. The next appearance above ground of a brood in our state will be in 1976 in two disjunct areas (several counties in the extreme southwest and several counties along the Wabash River); this brood has a 13-year life cycle.

Biochemistry and Pollution

One definition of a pollutant is a chemical agent which severely alters the biochemistry or physiology of an organism for such periods of time that the organism dies.

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The mechanisms of toxic action of many possible pollutants to aquatic organisms are not known; however, many hypotheses for their action have been suggested. For example rotenone, used for many years as a fish toxicant and as a tool in fishery management, was thought to cause suffocation of fishes by blocking the blood circulation in gills and destroying the gill tissue. Previously, it had been shown that rotenone reduced oxygen uptake by fishes and insects. European workers indicated that in severe rotenone poisoning the circulation in the gill tissue was normal, and the destruction in gill tissue was due to secondary changes. These workers found that rotenone inhibited the uptake of oxygen in the presence of pyruvate and glutamate, but not in the presence of succinate. Japanese workers also have made similar observations. It was further reported that rotenone inhibited the flow of electrons between substrate and oxygen. This has been the only biochemical action shown for rotenone.

Survey aquatic biologist, Robert C. Hiltibran, has been investigating the effects of possible pollutants on the oxygen and phosphate metabolism of bluegill liver mitochondria. Together with Mike Johnson, Hiltibran estimated the effects of rotenone on oxygen uptake by bluegill liver mitochondria and found that rotenone completely inhibited oxygen uptake at a level of less than a hundred thousandths of a gram of rotenone per milliliter of reaction medium, whereas at less than a millionth of a gram per milliliter oxygen uptake was not altered.

Hiltibran and his associates have investigated the effects of several herbicides, metals, and insecticides on the oxygen and phosphate metabolism of bluegill liver mitochondria. They have found that some herbicides, metals, and insecticides severely alter oxygen uptake in the presence of succinate as substrate, but did not alter the oxygen uptake in the presence of alpha-ketoglutarate as substrate. Further, some of the chemical agents did not alter oxygen uptake but altered phosphate uptake. To date, the effects of approximately 125 possible pollutants have been estimated. The data suggest that there must be some correlation between the observed biochemical effects and the toxicity of pollutants to bluegill.

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Control of the Fall Cankerworm

The fall cankerworm, *Alsophila pometaria,* feeds on many species of deciduous trees. The larvae emerge about the time spring foliage appears and may be so numerous that trees are nearly defoliated. When mature, the larvae drop from the trees on silken threads and pupate in the soil and in soil debris. Because of the ecological hazards associated with some of the chemicals formerly used to control the fall cankerworm, Survey entomologist J. E. Appleby with P. Bristol and W. E. Eickhorst of Morton Arboretum, Lisle, Illinois, initiated experiments to find less hazardous substances.

On May 15, 1973, seven lower branches were selected on each of three American linden trees that were heavily infested with fall cankerworm larvae in the next-to-last development stage. On each tree about six feet of the distal portion of each of the selected branches were covered with a nylon mesh bag. Just prior to treatment each bag was removed, sprays were applied, and the bag was replaced. Acephate, *Bacillus thuringiensis* (Dipel), Sevimol, Gardona, and malathion were sprayed on the selected branches. Each treatment was applied to three of the covered branches on each tree. On May 18, 1973, the bags were untied and opened, and the live and dead cankerworm larvae were counted on the branches, on foliage, and in each bag. In bags where the larval mortality was less

(Left) Fall cankerworm larva on an American elm leaf. (Photo by W. D. Zehr) (Right) Horse chestnut tree almost completely defoliated by the fall cankerworm. (Photo by J. E. Appleby)

than 90 percent, the bags were replaced, and counts were taken again on May 25.

The second experiment was initiated on May 22, 1974, on the trees used in the first experiment except that six branches on each tree were selected. The larvae were mature and feeding on the foliage. Prior to treatment, the live larvae were counted on each of the selected branches. The same insecticides, with the exception of Gardona, were applied in the same manner, except that bags were not used. On May 23, 1974, the live larvae were counted on the selected branches. Counts were repeated on June 1 on branches containing any live larvae.

In the first experiment three days after application, acephate, Sevimol, Gardona, and malathion gave excellent control, but no mortality was observed as a result of the *B. thuringiensis;* however, seven days later the *B. thuringiensis* treatments resulted in complete control of cankerworm larvae. The fact that no mortality resulted three days after the *B. thuringiensis* treatments is not surprising, as sufficient time is required for the bacteria of this insecticide to invade the body cavity. Larvae stop feeding soon after ingestion of a lethal dose of *B. thuringiensis* although the larvae may remain alive. Unfortunately, in some cities having municipal insect-control programs, the public is not informed about the expected results of this treatment, quickly conclude that the treatment is ineffective, and demand that another insecticide be used.

All insecticide treatments in the second experiment gave complete control one day after application, except *B. thuringiensis;* however, ten days after application no live larvae could be found on the branches in this treatment. No tree poisoning resulted from any of the treatments in either experiment.

In areas that have a history of cankerworm outbreaks, tree branches should be examined carefully for fall cankerworm eggs in late winter. If large numbers of eggs are found, branches containing eggs should be pruned and held at room temperature for about ten days to ascertain the viability of the eggs. If many eggs hatch, control preparations should be started. Unfortunately, in most municipal areas public complaints are voiced when the larvae are mature and damage has occurred.

Fungi in Freshwater Habitats

The role of the substrate, that is, the material that a fungus lives on, in determining fungal populations in fresh water is extremely important. Certain fungus species are encountered only on submerged woody substrates, while entirely different populations are found on submerged decaying leaves, or as parasites or saprophytes of algae and microscopic animals. Recent studies indicate that fungi play a unique role in preparing substrates for use as food by other microscopic animals and plants in freshwater systems.

Lee Crane, Survey mycologist, has therefore undertaken a study of three types of freshwater habitats in Illinois to determine which fungi are present and their distribution in fresh water. The habitats investigated were three artificial ponds, a midwestern river, and four freshwater swamps in southern Illinois. Blocks of balsa wood were submerged for one month in each of these habitats and were then collected along with natural substrates, such as submerged decaying leaves and wood. The balsa wood and natural substrates were incubated for one year in moist petri dishes. The incubated substrates were examined monthly to determine the kinds, relative abundance, and distribution of the fungi present.

This study indicates that there is a large, previously unknown population of fungi that colonize submerged wood and leaves in freshwater environments. Many of these fungi have unusual adaptations to the aquatic habitat in the form of four-armed or S-shaped spore forms which appear to aid in their dispersal in water. Preliminary studies also indicate that the relative abundance and the kinds of fungi observed on the incubated substrates vary according to the type of substrate and the season. Certain species, such as *Neta patuxentica* and *Stachybotrys atra,* are en-

Spores of *Flagellospora penicillioides* (left) and *Triscelophorus monosporus* (right). These fungi are typical of those that colonize wood and leaves submerged in fresh waters. The S shape of *F. penicillioides* and the four arms of *T. monosporus* appear to aid in their dispersal in water. (Photos by J. L. Crane)

countered in all seasons, while *Gonytrichum macrocladium* predominates during the summer months and *Conioscypha varia* is a cold-weather species. Considerably more study will be necessary before it will be possible to classify all of the fungi that Crane has found and understand how they interact with their substrates and with other organisms.

Additional Experiments with the White Amur

The white amur, or grass carp, is extremely controversial because of its potential threat to some of our native fishes and to aquatic ecosystems should it establish breeding populations. The extent of such damage is unpredictable, but it could be great and almost irreversible. For this reason the Illinois Department of Conservation has banned the importation of the white amur into Illinois, except by written permit to qualified research agencies, and this action is fully endorsed by the Illinois Natural History Survey.

On the other hand, the fish has rather remarkable capabilities of such great potential value that further study is definitely warranted. The white amur consumes large quantities of potentially noxious aquatic plants and recycles the released nutrients to the benefit of associated fish species, and it can grow rapidly and produce highly desirable food on a diet of coarse vegetable matter. Aquatic biologist Homer Buck believes that there could be great value in exploiting these capabilities under properly controlled conditions.

In 1973 Buck and his associates conducted experiments in ten-foot diameter plastic pools to (1) measure the influence that the white amur might have on associated fishes through its continuous recycling of the nutrients stored in the tissues of aquatic plants, and (2) compare the biological control of plants by the white amur with control by chemical means (diuron). They found that the use of the white amur permitted a "bonus" production of fish (the weight of the white amur was almost double that of the companion fishes) without loss in production of the associated bluegills and shiners. At the same time a desirable level of control of both waterweeds and filamentous algae was achieved with less effort and expense than would be required with a herbicide and without the possible side effects of a chemical.

In 1974 they extended the study to eight 1-acre ponds, four of which contained largemouth bass (LMB) and bluegills, and the other four, smallmouth bass (SMB) and bluegills. Each of four ponds (two having LMB, two having SMB) was stocked in mid-April with 18 white amurs weighing approximately one pound each. All of these ponds have a history of rather heavy growths of weeds (mostly *Potamogeton* and *Najas*) or of filamentous algae.

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These are the first year's observations:

1. The survival of white amurs through the growing season was 100 percent, and their growth was equally impressive, some individuals attaining weights of eight pounds (as much as seven pounds of gain in five and a half months), with an average weight of 5.74 pounds.

2. The removal of vegetation was complete, suggesting that satisfactory control could have been achieved with less than 18 one-pound fish per acre.

3. The removal of vegetation in the largemouth ponds increased the vulnerability of small fish to predation. This fact caused a desirable reduction in numbers of small bluegills and faster growth by surviving bass and bluegills, but it also caused such severe decimation of young-of-the-year largemouth bass that the survival of the bass population was endangered.

4. The effect was similar but less pronounced in the smallmouth ponds, reflecting the less predacious nature of the smallmouth bass. Bluegill populations were less effectively reduced in the weedless ponds which contained white amurs, and the survival of young smallmouth bass was substantial and not significantly different than it was in the weedy ponds containing no white amurs.

A final word of caution. Results to date are only tentative and it is now unknown whether potential benefits will outweigh the potentially harmful effects of the white amur. This report should by no means be considered a recommendation for the use of this highly controversial species.

Cicadas Publication Available

All Survey publications are available to interested persons who request them as well as to libraries and research organizations. A booklet on periodical cicadas, reported on in the May issue of *INHS Survey Reports,* has recently been published. If you want more information on this subject, write to Dr. George Sprugel, Jr., Chief, Illinois Natural History Survey, Natural Resources Building, Urbana, Illinois 61801, and ask for Biological Notes No. 91, *The Distribution of Periodical Cicadas in Illinois.*

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SEPTEMBER 1975 NO. 14[illegible]

Freezing Stresses and Plant Disease

Most disease organisms that cause stem cankers and diebacks of trees and shrubs only attack plants that are low in vigor or are suffering from some type of stress. The appearance of stem diseases is often associated with unfavorable environmental conditions, such as drought, flooding, or rapid and extensive drops in temperature that occur when cold fronts move through in the fall or spring. Such diseases are also common on plants weakened by transplanting or defoliation.

Although this association between disease and plant stresses is common knowledge among plant pathologists, little is known about how stresses affect disease susceptibility or what mechanisms in the host plant prevent disease organisms from attacking the tissues. The main barrier to gaining such knowledge has been the lack of workable techniques to control environmental stresses for plant disease research.

In recent years, Survey plant pathologist D. F. Schoeneweiss has succeeded in developing model systems for exposing plants to controlled drought, freezing, and defoliation stresses. One of these systems involves the differential freezing of stem tissues on intact, container-grown trees and shrubs.

Portions of the test stems are wrapped with pipe insulation and heating cables, whereas other portions are left exposed. The plants are then placed in a large walk-in freezing cabinet and the air temperature is lowered at a controlled rate to well below the freezing point. Some of the plants are removed at each of several predetermined freezing levels. When insulated (unfrozen) and frozen stem portions are inoculated with canker disease fungi, changes in disease susceptibility associated with freezing stress can be detected.

Results thus far indicate that disease resistance in dormant woody stems breaks down following exposure to levels of freezing temperature that are not low enough

Tree seedlings placed in a programmed freezing cabinet. Roots and portions of the stems are insulated to prevent freezing. (Photo by D. F. Schoeneweiss)

to cause direct freezing injury or dieback. Thus, damage commonly attributed to a sudden disease outbreak may actually be a secondary effect of a stress that occurred some time earlier, predisposing the plant to disease.

Another advantage to the differential freezing method is that stem tissues resistant and susceptible to disease are present on the same intact stem, which makes an ideal system for studying the mechanisms responsible for disease resistance. Determining what mechanisms are responsible for disease resistance in woody stems and how these mechanisms are affected by environmental stresses are objectives of continuing research at the Survey. The knowledge gained should find application in developing recommendations for preventing damage by disease organisms that attack plants under stress.

Land-Use Trends Disastrous to Prairie Chickens, Quail, and Rabbits

Assessing losses of habitat and declines in wildlife populations on private land is often difficult because of the absence of records. Fortunately, such records exist for 1939 for a 2,760-acre area near Hunt in Jasper County thanks to the efforts of the late Survey wildlife biologist, Dr. Ralph E. Yeatter, and Charles S. Spooner, Jr.

Yeatter conducted counts of booming prairie chickens on the area each spring, 1936-1963, and he censused quail and rabbits in October, using bird dogs. Spooner mapped the game cover of the area in detail in 1939. Survey wildlife biologist D. Russel Vance duplicated the censuses and cover-mapped the area again in 1974.

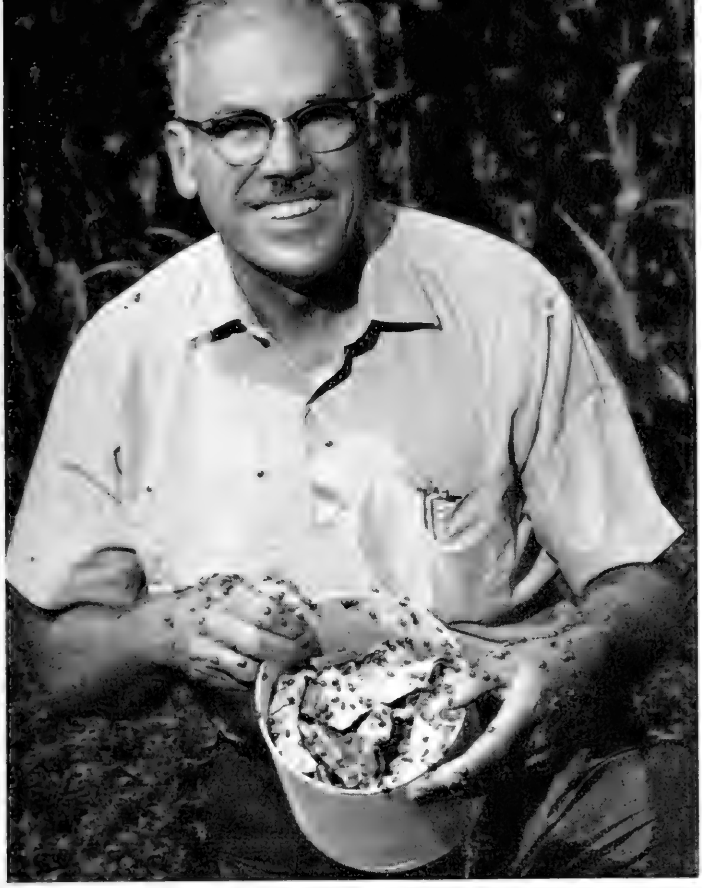
Vance found that the rapid intensification of cash-grain farming during the past 35 years has dramatically altered the landscape of the Hunt area and has decimated the prairie chicken, quail, and rabbit populations. In 1939 grassy cover (including pastures and redtop and timothy harvested for seed or hay) constituted 47.1 percent of the area. In 1974 only 1.0 percent of the area remained in grass, and this remnant was primarily overgrazed pasture. Soybeans, then used mainly for hay, covered only 9.4 percent of the area in 1939. In 1974 soybeans were planted on 68.8 percent of the land. As cash-grain farming expanded, average field size more than doubled (from 10 acres to 23 acres) at the expense of fencerows. In 1939 the 2,760-acre Hunt area contained about 43 linear miles of woody fencerow in the medium and dense categories. Now the area contains less than 6 miles of good fencerow cover.

The extensive loss of habitat in the past 35 years has resulted in equally dramatic losses in prairie chicken, quail, and rabbit populations. Yeatter found at least 131 prairie chickens booming on the Hunt area in the spring of 1939; none have been seen there since 1968. Yeatter flushed 226 quail on two sections of the area in 1939, a density of 15.3 quail per 100 acres. Vance found only three coveys totaling 49 birds on these two sections in 1974, a density of only 3.3 quail per 100 acres. Yeatter also flushed 57 rabbits on the area in 1939, a ratio of 2.07 rabbits flushed per 100 acres. During the 1974 census, two rabbits were flushed, a ratio of only 0.07 rabbit flushed per 100 acres.

As the trend toward clean farming intensifies in southeastern Illinois, only those sites left by accidents of topography or by the decisions of individual farmers will contain the brushy, grassy cover essential for the existence of many species of wildlife. The current world food crisis makes it very unlikely that the game cover we once had will soon be reestablished on Illinois's highly productive soils.

Ladybug, Ladybug, Fly Away (to Your New) Home

As we all know, ladybugs, also called ladybird beetles, are abundant in Illinois, and most species feed on other insects or their eggs. Thus, they help to control insects that damage agricultural crops and ornamental plants. In their quest for natural, in addition to chemical, means of controlling harmful insects, Survey entomologists have recently introduced a new species of ladybug into Illinois in the hope that it will be even more effective than



Survey entomologist Clarence White preparing to release ladybugs in a cornfield. (Photo by Larry Farlow)

native species. The new ladybug is about twice the size of the native ladybug, and it feeds voraciously on aphids.

The story goes back to November 1974, when Dr. William Luckmann, head of the Survey's Section of Economic Entomology, visited with Dr. Richard Dysart, formerly with the Survey and now with the USDA Beneficial Insects Research Laboratory in Newark, Delaware. Dr. Dysart mentioned that a colony of ladybugs of the species *Coccinella septempunctata,* commonly found in Europe, had become established at Lyndhurst, New Jersey.

Survey entomologists Luckmann and Clarence White asked the USDA to send them some of the beetles for further study. Accordingly, in March 1975 they received 100 ladybugs from Dysart, and the insects were placed in special cages in Survey laboratories and greenhouses. The beetles thrived on an aphid diet and produced a new generation.

When the ladybugs became abundant in New Jersey this summer, the Survey researchers were informed that August 1 would be about the right time to collect large numbers of the beetles. White made the trip to Lyndhurst, and on August 1 and 2 (with the help of two members of his family, who traveled at their own expense) collected more than 4,500 ladybird beetles.

After White's return with his collection, he and Luckmann released the ladybugs on August 5 in fields of corn, sorghum, and alfalfa on the Illinois Agricultural Experiment Station farms, Urbana. During August the beetles were observed feeding on corn leaf aphids colonizing on corn and sorghum. The beetles will be carefully watched during the late summer, fall, winter, and spring to determine their dispersal and whether they successfully establish permanent residence here.

Herbicides and Bluegills

For many years derivatives of the herbicide 2,4-D have been used in efforts to rid farm ponds, lakes, and other waters of excessive growths of aquatic plants. In a previous report Survey biochemist Robert Hiltibran stated that the 2,4-D derivatives had been found to be about equally

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effective against such aquatic plants as northern water milfoil and coontail. However, the different derivatives of this herbicide had been found to have different levels of toxicity to bluegills.

As a part of his investigation of herbicides in the aquatic environment and their effects on fish, Hiltibran and his associates decided to attempt to determine why various 2,4-D derivatives affected bluegills in different ways. Thus began a study of the effects of the 2,4-D derivatives on the oxygen and phosphate uptake of bluegill liver mitochondria (minute, granular, rodlike or threadlike lipoprotein complexes in the cytoplasm of most cells).

The 2,4-D derivatives, or esters, could be placed into two general groups. The first group includes the larger and heavier esters, which, because of their greater molecular weights, are commonly called high-molecular-weight derivatives. These include the propylene glycol butyl ether (PGBE), or isooctyl, esters. The second group contains the smaller and lighter 2,4-D esters, such as isopropyl and butyl esters, which contain three and four carbon atoms, respectively, and are commonly referred to as low-molecular-weight esters.

Hiltibran found that the isopropyl and butyl esters of 2,4-D decreased oxygen and phosphate uptake of bluegill liver mitochondria more than did the isooctyl ester. However, other high-molecular-weight esters (PGBE) of 2,4-D decreased oxygen and phosphate uptake more than did low-molecular-weight esters, such as the ethyl ester of 2,4-D.

These observations indicated that a simple relationship between molecular weight and biological effects did not exist. Further, those 2,4-D derivatives which were more toxic to bluegills altered oxygen and phosphate uptake more than did the 2,4-D derivatives which were less toxic to bluegills. These results suggest a correlation between the biochemical effects on oxygen and phosphate uptake and the toxicity of these 2,4-D derivatives to bluegills. The data indicate a specific interaction between each 2,4-D derivative and each enzyme complex which could not be predicted on the basis of molecular weight.

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OCTOBER 1975 NO. 15[illegible]

Ground-Nesting Bee

Andrena erigeniae is a solitary bee about half the size of a honey bee. Solitary means that each female bee builds her own nest, and provisions each cell with pollen and nectar by herself, and lays an egg on the pollen ball. In the case of *Andrena erigeniae,* which can be called the spring-beauty bee, the nests are short burrows in the ground with cells excavated in the ground near the bottom of each burrow.

The nest biology of the spring-beauty bee is described and illustrated in the Survey's *Biological Notes No. 95* (June 1975) by Lloyd R. Davis (now located at the University of Florida) and Survey entomologist Wallace E. LaBerge. This biological note can be obtained from the Chief of the Survey upon request.

The spring-beauty bee is so named because the females depend entirely upon pollen and nectar from spring beauties (*Claytonia virginica*), a beautiful spring flower which carpets the forest floor of many Illinois' woodlands before the leaves of the trees have emerged. The bees nest in the forest soil in well-drained areas. The burrow excavated by the female is short, being only 6.5 to 15 cm below the surface, and from 3 to 14 horizontal cells are attached to the bottom of each burrow. Fecundity of the female seems low, but reproductive success must be very high, as these bees are usually abundant in woods where spring beauties abound. Nesting begins about the first of April and is finished by mid-May in the latitude of Central Illinois.

The bee larva hatches from its egg, devours its bee-bread (a spherical ball of pollen and nectar) and pupates in the cell by late July. The adult emerges from the pupa in September and remains in the cell until the sun warms the soil in early spring.

Davis and LaBerge describe a fly which acts as a kleptoparasite (stealing the bee larva's bread). The fly locates a bee's burrow by following the bee. The fly enters the burrow after the bee has left and deposits one or more eggs in the burrow. The fly larvae locates the cells and eats the bee larva's provisions causing the death of the bee larva.

The spring-beauty bee is the most important pollinator of spring beauties. Without this bee these plants would produce

Andrena erigeniae collecting nectar from a flower of *Claytonia virginica*. (Photo by Lloyd Davis)

fewer seeds, at least be scarce, and would not grace our early spring woodlots as it now does.

Thrips and Soybeans

An outbreak of soybean thrips, *Sericothrips variabilis,* occurred early in the season in the southern half of Illinois. Particularly heavy infestations were noted on soybeans at Effingham, Dale, Harrisburg, and Dixon Springs. Survey entomologist L. J. Stannard in cooperation with the Survey's economic entomologists has maintained surveillance of soybean thrips and mites throughout the past summer.

Unifoliate and trifoliate soybean leaves, if not completely destroyed, turned yellow as the result of thrips feeding on them. In one instance, over 800 thrips were found on a sample of 20 leaflets in the Harrisburg area. Such great numbers so early in the season is believed to have been due to the mildness of last winter. An outbreak had been anticipated, in fact, because winter monitoring had revealed active thrips on clover on warm days in January and February as far north as Monroe County.

Although the soybean thrips had not previously appeared in epidemic numbers, Stannard was fortunately well prepared to meet the unexpected situation. One of his students, T. C. Vance, in 1974 had published in the Survey's Bulletin series a life-history study of this species and had discovered that a predacious anthocorid bug, *Orius insidiosus,* could provide excellent biological control.

Concerned farmers in southern Illinois were asked by Extension entomologists via radio and letters to county farm advisers not to spray for thrips control until Survey entomologists could assess the magnitude of the outbreak. Intensive monitoring of the areas revealed that, as expected, within three weeks large populations of *Orius* had developed and decreased the number of thrips to below economic levels. The resultant high numbers of the predators also aided in control of species of Lepidoptera that invariably deposit eggs on soybean leaves later in the summer. Thus, while some damage was done to the crops early in the season, the appearance of large numbers of *Orius* insured less damage by other pest species for the remainder of the growing season. The censusing data on thrips and *Orius* are presently being analyzed.

When harvest data become available this fall, a publication will be prepared describing this near classic case of sound biological control and practical application of basic research data. The presence at the Survey of a thrips specialist, who had just completed a study of the genus *Sericothrips,* spared soybean farmers in southern Illinois substantial amounts of money that they might have spent unnecessarily on chemical sprays.

Pheasant Population Increases

Former Survey wildlife biologist G. Blair Joselyn estimated that in 1974 the late summer pheasant population on the Sibley Study Area and Ford County Management Unit had declined 40 to 50 percent from 1973. In the following fall and winter, poor hunting success and mild weather resulted in relaxed survival pressures for the pheasant populations.

In 1975 wildlife biologist Richard E. Warner concluded from roadside census data collected in April and May that the breeding population was 50 to 60 percent lower than in 1974. Roadsides, small grains, hay, pasture, and nonagricultural cover on the Ford County Management Unit study area yielded an estimated 510 successful nests in 1973, 297 in 1974, but only 165 in 1975.

In contrast to the decline of successful nests in cover types, early morning brood counts during August of 1975 revealed a substantial increase in pheasant broods over 1974. In the Ford County study area this increase was from 17.1 broods per 100 miles in 1974 to 54 broods per 100 miles in 1975.

The incongruity between early season nesting studies and the later brood census is clarified by two considerations. First, the weather conditions at the time brood counts were made may have contributed as much as 50 percent of the difference. In 1974 at the time of the brood census there was little

Pheasants along a roadside in Illinois as seen by the census-taker. (Photo by former Survey photographer W. E. Clark)

or no dew in the mornings, whereas in 1975 heavy dew was present. From other studies, it is known that such a difference in dew is a significant factor causing variation in brood counts. Second, weather conditions in 1975 permitted early planting of row crops such as corn and soybeans and early cultivation of these crops, in contrast with 1974 when wet weather delayed planting. This permitted successful nesting in the soybean and corn fields, not counted in the nesting surveys early in 1975.

The outlook for the 1975 pheasant hunting season in Illinois is encouraging. A conservative estimate, in view of the 1975 August brood census, is that there are two to three times as many pheasants this year as compared with 1974. Furthermore, crops ought to be harvested earlier in 1975 than in 1974 and pheasants ought thus to be concentrated in the remaining cover areas.

New Golf Course Grubs

A new pest of annual bluegrass and bent grasses in golf courses has been discovered damaging greens in St. Clair and Madison counties in Illinois. This pest is the grub of a small beetle, *Ataenius spretulus* Harold, which has not been given a common name as yet. Survey entomologist Roscoe Randall has been following the damage reports from Illinois and devising recommendations for control of the grubs.

The beetles are about a quarter of an inch in length, appear as adults in August, and overwinter as adults in decaying vegetation such as grass clippings or in cowdung or fungus. In May or June they lay eggs in the turf. The larvae feed by clipping the roots of the grass at or near the surface. As a result, the grass wilts, turns brown and the sod can easily be lifted from the soil in patches. The larvae are full-grown by mid-July and pupate in the soil.

This insect was first reported in Illinois by Stephen A. Forbes in 1905 who suggested that it might become a pest in this state. It was first reported as a pest of turf grasses in golf courses in Minnesota in 1934 and then in New York in 1969. In 1974 it was reported to be destroying turf grasses in Cincinnati, Ohio, and in golf courses in St. Clair Co., Illinois. In 1975 reports indicated that the grubs are affecting turf grasses in golf courses in several eastern states.

The grubs were found to attain populations as high as 240 per square feet in bent grass and annual bluegrass greens in Illinois in 1975. The peak of damage occurs between July 4th and 25th in northern Illinois and control measures need to be applied early during an infestation. Organic phosphate soil insecticides such as Dylox, Proxol, Dasanit, and Diazinon have been used to control the grubs. Roscoe Randall reports that Proxol was applied to an in-

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festation in northern Illinois with good results.

The damage caused by this grub in 1976 will depend on the success of overwintering of the adults and the amount of egg laying in the spring. The insect may be a minor pest to turf grasses, but could increase in importance, at least locally.

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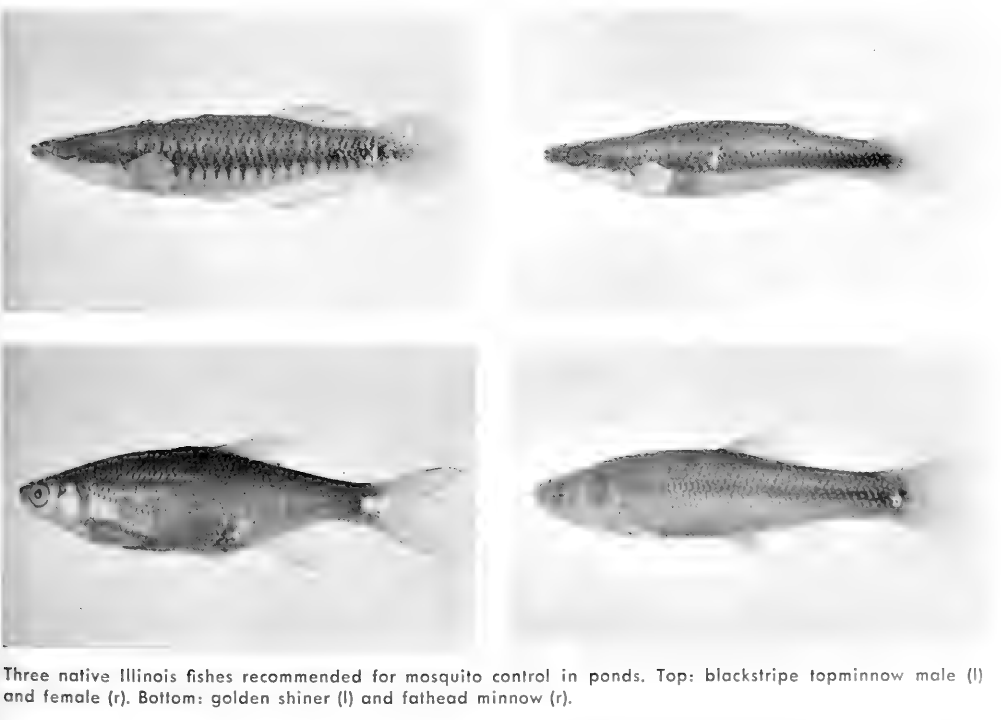
NOVEMBER 1975, NO. 151

Control Mosquitoes with Minnows

St. Louis encephalitis in epidemic proportions precipitated serious concern throughout most of Illinois in the late summer and fall of 1975. Since adult mosquitoes transmit the disease, Survey scientists received numerous inquiries from agencies and individuals about the control of mosquito larvae (wrigglers) in proposed and existing ponds, borrow pits, and backyard goldfish pools. Survey ichthyologist P. W. Smith recommends a trio of small native fishes for introduction into such ponds, but he acknowledges that many other native species might be extremely useful if detailed studies of their food habits could be funded.

The three species presently recommended are the blackstripe topminnow, the golden shiner, and the fathead minnow. All are common and widely distributed native minnows. The topminnow has its mouth on the top of its head; the other two fishes have sharply upturned mouths. All three feed at the surface and in midwater and presumably prey on mosquito wrigglers, although to what extent is unfortunately not known at present. Tolerant



Three native Illinois fishes recommended for mosquito control in ponds. Top: blackstripe topminnow male (l) and female (r). Bottom: golden shiner (l) and fathead minnow (r).

of water with no flow over a substrate of silt or clay, they can stand a certain degree of pollution and high water temperatures and are thus admirably suited for introduction into small artificial ponds.

In the past the gambusia, or mosquitofish, has been widely used to control larval mosquitoes, but it is native only to extreme southern Illinois. The modern, enlightened view is that animals and plants should never be introduced outside their natural ranges because of the risk that exotic species may upset the ecosystem. Fortunately, the blackstripe topminnow and golden shiner exist virtually statewide in Illinois, and the fathead minnow occurs in all parts of the state except in the Wabash and Ohio drainages.

If it is desirable to stock other species to provide fishing for children, Smith recommends the yellow bullhead and black bullhead. Sunfishes and basses, which have more appeal to adult anglers, would prey on the small fish. However, bullheads are bottom feeders and scavengers and much less predatory. Goldfish have similar habits and are ornamental, but they are neither sport fish nor native to Illinois.

The three recommended fishes are easily recognized. Regional fishery biologists of the Department of Conservation may be contacted for local sources of these minnows. If other questions should arise, write to the Chief, Illinois Natural History Survey, Urbana 61801.

Tree and Shrub Problems Diagnosed

Each year the Survey's Section of Botany and Plant Pathology receives many tree and shrub samples for disease diagnosis. Most of the samples are received from May through September. Between January 1 and September 30, 1975, plant pathologist Gene Himelick and his associates received 1,712 samples. Included were 722 elm samples to be cultured for the Dutch elm disease fungus, 85 samples of trees and shrubs to be cultured for wilt diseases, and 905 tree and shrub samples, most of which were examined microscopically to diagnose the specific disease.

A total of 190 plant samples were brought directly to Himelick's office for disease diagnosis. He received approximately 550 phone calls requesting measures for disease control.

The persons who seek these services are homeowners, farm advisers, nurserymen, arboriculturists, and others.

The most prevalent problems encountered this year have been chemical injuries resulting from the use of weed killers, wilt and canker diseases, needle diseases of pines, and a condition called spring leaf tatter, which occurs on many tree species but appears to be most common on maples.

Chemical injury to trees and shrubs resulting from the use of herbicides in lawns was a serious problem throughout most of Illinois this year. In many cases unusual climatic conditions in late spring appeared to be related to the increasing amount of plant injury and number of deaths. Most tree and shrub species are highly sensitive to 2,4-D and 2,4,5-T, and Himelick recommended that their use be avoided as much as possible in residential areas. Other chemical injuries appeared to result from spray drift, which often occurs when chemicals are carelessly applied on a windy day. Some of the other chemicals involved are those applied for mosquito abatement in residential areas and for weed control along roadways and on corn and soybean crops.

Oak trees are declining in many areas of northeastern Illinois. Much of the death and decline is due to the excessive rains that occurred in the springs of the past two or three years. Other oak decline problems appear to have resulted from past heavy defoliation by insects, such as the spring canker worm, and from construction injury. New homeowners have continued to write or call concerning the losses of large numbers of oaks around their homes in recently developed subdivisions. Since oak species are quite susceptible to site disturbances and oaks are the predominant species, the tree loss in most subdivisions has been very high in all of Illinois in the past few years.

Many samples of maples and oaks which appeared to be suffering from spring leaf

Tulip tree leaves (l) and maple leaves (r) that are cupped, distorted, and yellowed as the result of chemical injury. The herbicide 2,4-D was used on the lawns around these trees.

tatter were received. This condition causes the tissue between the leaf veins to turn brown, and a large percentage of the total foliage area is killed. The cause is believed to be a physiological problem related to specific climatic conditions. It is most severe when the leaves are very succulent after abundant spring rains and cool nights, followed by drying winds.

Some of the other tree and shrub problems encountered were Verticillium wilt; oak wilt; anthracnose of sycamore, ash, and maple; pin oak chlorosis, which causes the leaves to turn yellow from lack of iron; drowning of roots from excessive rains, which cause root suffocation; deaths from transplanting shock; several leaf spot diseases; winter injury; mechanical injuries caused by lawnmowers and construction machinery; and other problems caused by such animals as insects, squirrels, birds, and dogs.

Mercury Studies at Lake Sangchris

The investigation of the physical and biological dynamics of mercury at the Kincaid Power Plant–Lake Sangchris complex in central Illinois has been completed by chemist Dr. Kenneth E. Smith and wildlife biologist William L. Anderson. The study included the collection and analysis of samples of coal, slag, fly ash, airborne particulate matter, soil, lake sediment, fish, plants, and ducks. These materials were analyzed by cold-vapor atomic absorption spectrophotometry, a technique that is capable of detecting less than 0.001 part per million (ppm) of mercury.

The Kincaid Power Plant consumed 2.7 million metric tons of coal during the year the study was conducted. From the mean concentrations of mercury found in the coal, slag, and fly ash (0.20, 0.039, and 0.037 ppm, respectively), it can be estimated that 530 kg of mercury, or 97 percent of the mercury contained in the coal, was volatilized and emitted into the atmosphere through the smokestacks.

Analyses of the soils surrounding the plant show that the highest mercury concentrations (0.022 ppm) are to the northeast of the plant and the lowest (0.015 ppm) are to the southwest. This distribution was expected, as the locally prevailing winds are from the southwest. Estimates of the amounts of mercury in the soil above the natural background values account for up to 68 percent of the total mercury emitted from the power plant.

Mean concentrations of mercury in the lake's sediment were higher (0.049 ppm) in deposits occurring after the power plant began operating in 1967 than in deposits made earlier (0.037 ppm). The total amount of mercury in the sediment estimated from these values accounts for only 1 percent of the power plant's probable emissions of mercury.

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It seems, however, that these mercury emissions are not accumulating in the fish that inhabit Lake Sangchris. All of the 120 fish analyzed, representing seven species, contained surprisingly low amounts of mercury in their lateral muscle tissues, the edible portion of the fish. For example, total mercury averaged only 0.07 ppm in the filets of largemouth bass, only 10 to 50 percent as great as concentrations in largemouth bass from three other lakes in central Illinois. It appears that some unidentified factor in the environment at Lake Sangchris has suppressed mercury accumulations in the fish.

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DECEMBER 1975, NO. 157

Some Rare Fishes Saved

In 1970 the U.S. Department of Agriculture Forest Service reclassified some of its swamp holdings in the Shawnee National Forest of Union County from the Pine Hills Scenic Area to the LaRue-Pine Hills Ecological Area. The new and unprecedented classification was designed to give protection to some of the unusual plants and animals and to their habitats in this unique spring-fed swamp.

The Forest Service contracted with the Illinois Natural History Survey to do a year-long study of some of the threatened and unique fishes in the swamp. The species selected for intensive study were the banded pygmy sunfish, spotted sunfish, bantam sunfish, starhead topminnow, and spring cavefish. Survey ichthyologists conducting the study were J. M. Boyd, B. M. Burr, L. M. Page, and P. W. Smith. The results of the investigation have just been released by the Forest Service in a booklet entitled "Those on the brink of doom: A study of rare fishes in the Shawnee National Forest."

Survey ichthyologists visited the swamp once each month throughout the year to collect physical and chemical data and to make quantitative samples (number of fish per square meter) of fishes at eight preselected stations. On each visit additional sites were examined to see if the rare species occurred elsewhere in the Shawnee National Forest. The Survey team found that populations of the banded pygmy sunfish, starhead topminnow, and spring cavefish were higher in the swamp than had been anticipated, and that all five species studied also occurred elsewhere in the Shawnee National Forest. As a result, the scientists recommended that the Forest Service could, if it chooses, remove the banded pygmy sunfish and starhead topminnow from the list of species that may not be collected even by permit. They also recommended that the spotted sunfish be added to the list of protected species. Other

View of swamp habitat (photo by P. W. Smith).

specific recommendations to manage and protect all of the fish species and their habitats were included.

Thanks to the foresight of authorities in the Forest Service, the status of each of the unique species is now known, and the future of several seems secure within the Ecological Area, where every effort is made to protect them. The Forest Service is also to be commended for seeking expertise from Survey ichthyologists already familiar with the swamp and for establishing guidelines for the management of the Ecological Area based on Survey recommendations.

Pesticides and Environment

Modern agricultural practices, such as use of superior plant varieties, improved cropping methods, high-nitrogen fertilizers, insecticides, and herbicides, have been responsible for immense increases in the productivity of Illinois croplands. These practices are responsible for Illinois corn yields increasing from 30 bushels per acre in 1920 to 105 bushels per acre in 1973. The use of pesticides has been described as being as "significant as the plow." Pesticide use has increased phenomenally and many of the chemicals used are dispersed throughout the environment, entering air, water, and food through volatilization and air currents, runoff and leaching, and uptake and concentration in food chains.

Rapidly changing agricultural technology and rapid introduction of new chemicals present a continuing demand for evaluation and surveillance of the effects of pesticides on environmental quality. New pesticides are being introduced at a much faster rate than is our scientific appreciation of their side effects. During the 30 years since World War II, the number of different chemicals used on farms has risen from less than 100 to over 900. During 1974 alone 10 new pesticides were introduced into Illinois under experimental permits.

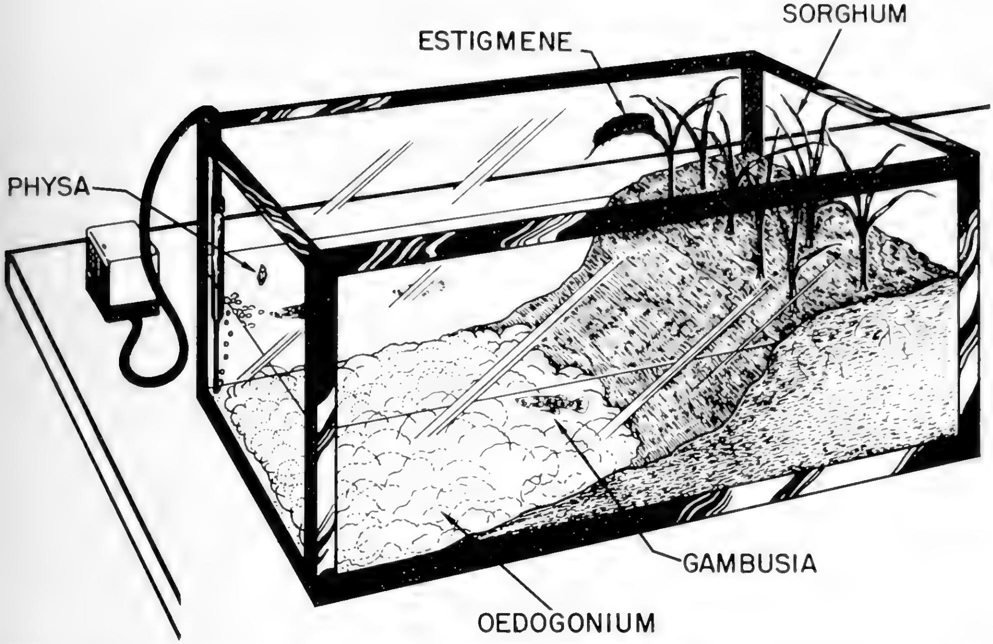
The use of pesticides in large quantities and their rapid introduction have prompted a real need for a screening method which could serve as a simple early-warning system against potentially undesirable or hazardous effects of new chemicals or combinations of chemicals. The wait-and-see system operating in the past, requiring a generation or more to recognize side effects which are harmful or even disastrous to the environment, simply is not tenable for the future.

The development of the model-ecosystem technology by Survey entomolgist Robert L. Metcalf has provided a quick and sensitive laboratory tool for providing answers to questions about environmental pollution by pesticides. Basically this system uses radiolabeled pesticides to follow the movement and degradation of the chemicals from a terrestrial (farm) to an aquatic (lake) environment and to demonstrate passage of the compounds or their derivatives through aquatic food webs. This is accomplished in the laboratory in an aquarium containing both terrestrial and aquatic organisms.

Survey entomologists Robert L. Metcalf and James R. Sanborn report on the results of testing 48 pesticides using the model-ecosystem technology in a published report entitled "Pesticides and environmental quality in Illinois" (*Illinois Natural History Survey Bulletin,* volume 31, article 9, August 1975). This technical report can be obtained upon request from the chief of the Survey.

Pollutants and Bluegill

"Out of sight, out of mind" is a cliché which frequently seems to apply to the disposal of wastes and may have contributed to the use of water for the disposal of wastes. Water is a very convenient disposal medium and appeared to work satisfactorily when the waste products from the primary life support systems were of biological origin, human populations were relatively low, and the quantity of wastes entering the water did not exceed the capacity of the biological life in the water to degrade the materials. The development of the chemical industry, in part a response to the need for additional food and fiber for a greater number of people, placed greater stress on the aquatic system. Wastes are now being placed in lakes, streams, and



Drawing of a model-ecosystem. The aquatic environment is represented on the left with fish, snails, and aquatic plants, the terrestrial environment on the right with sorghum seedlings and a caterpillar.

rivers that aquatic biological systems cannot utilize or decompose. Although man is not directly affected by the systems of disposal, the aquatic fauna are affected, since they are immersed in the disposal medium. However, man has been found to be indirectly affected by these same pollutants.

Robert C. Hiltibran, Survey biochemist, and his associates have been investigating the biochemical effects of possible pollutants on one member of the aquatic system, the bluegill. One aspect of this investigation is the bluegill's uptake of chemical agents directly from water and their distribution in the various tissues of the bluegill.

Much has been written about the accumulation in fishes of chemical agents that have found their way into the aquatic environment. The food web is one of the routes by which fishes accumulate chemical agents within the aquatic environment, as has been shown by the results obtained using the model-ecosystem. However, Hiltibran and his associates have found that bluegill removed 98 percent of the C^{14}-labeled DDT directly from water during a 48-hour period of exposure, and most of the DDT was removed during the first 24 hours of exposure. The fish were not fed during the exposure periods. In contrast, Hiltibran and associates found during the same exposure period that the bluegill removed from 1 to 3 percent of the C^{14}-labeled 2,4-D or 2,4,5-T directly from water. Thus the body burdens of these chemical agents would be considerably different.

The bluegill rapidly removed methoxychlor from water during the first 24 hours of exposure, but during the second 24-hour period of exposure C^{14}-labeled products were excreted into the water by the bluegill. Since it is known the methoxychlor is metabolized by fishes, these products were assumed to be methoxychlor or the metabolic products of methoxychlor. Further, the chemical concentration in bluegill tissues is less after 48 hours of exposure than after 24 hours of exposure. Similar patterns have been observed for several other agents investigated.

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Many of the pollutants to which the aquatic fauna are exposed are toxic to bluegill. How the toxicity is mediated is not known. In order for the toxic effect to be observed, either the biochemistry or physiology of the fishes is altered to such an extent or for such periods of time that the bluegill cannot survive. Hiltibran and his associates have also been investigating the biochemical effects of many of the above pollutants, but additional data are needed before the mode of toxic action of pollutants can be fully explained.

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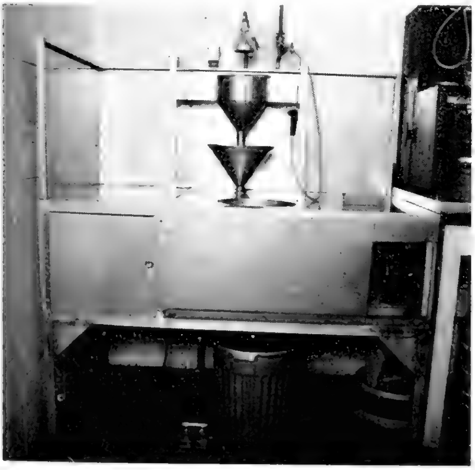
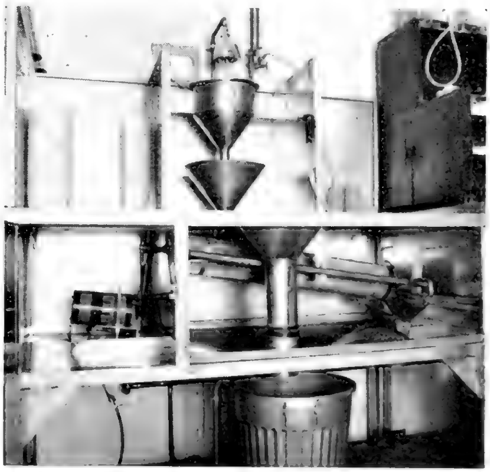
"Washing Machine" Extracts Corn Rootworm Eggs from Soil

The northern and western corn rootworms are well-established insect pests in Illinois cornfields. They deposit their eggs in the soil in August and September. The eggs develop slightly, go into a resting stage during the winter, and hatch in the following spring. The potential for damage by the larvae of these insects in the next growing season can be determined by counting the number of eggs per unit of soil. However, it is physically impossible to count these eggs without some means of extracting them from the soil, since rootworm eggs are about the size of the period at the end of this sentence.

About 10 years ago researchers at the University of Missouri developed a machine for separating rootworm eggs from soil. A sample of soil containing eggs was saturated with sodium hypochlorite and water, and the sample was agitated for 15-20 minutes on a ball mill. The sample was then passed in small amounts through a slowly revolving screen cylinder and washed with sprays of water. The eggs were collected in a fine-mesh screen trap for final processing.

Using the basic design of the Missouri separator, John Shaw of the Section of Economic Entomology and Robert Ellis of the Section of Administrative Services refined that design and engineered and





"Washing machine" which extracts corn rootworm eggs from samples of soil. In the left picture all covers and doors are in place, and in the right picture they have been removed. A soil sample is placed in the sieve located inside the funnel at the top and is washed with water from the shower head (controlled by a foot pedal). The water, carrying soil particles and eggs, runs down into the revolving, inclined screen cylinder and finally into a collecting trap. Soil and waste water are collected in the garbage can beneath the machine. When in operation, the electric motor is protected by a steel mesh shield.

constructed a larger, enclosed machine that extracts rootworm eggs from a pint of soil in only 3-4 minutes. The final stages of separating eggs from debris require another 5 minutes after which the eggs can be counted under a microscope.

The Illinois Natural History Survey machine and the final separation of eggs, using magnesium sulphate, are highly efficient, and the entomologists have repeatedly recovered 97 percent of rootworm eggs manually placed in samples of soil. Scientists working in the weed pest-management program of the Department of Agronomy, University of Illinois, also have used the machine to extract weed seeds from soil samples.

The Natural History Survey will soon publish an illustrated leaflet describing the machine and giving its dimensions and information about its operation and construction. When more such "washing machines" have been constructed, they should greatly help farmers, county agricultural advisers, agricultural researchers, and others who wish to predict the numbers and damage potential of corn rootworms in the next growing season.

Largemouth and Smallmouth Bass Diets

As part of their continuing study of the largemouth and smallmouth bass life histories, aquatic biologists Homer Buck and Richard Baur monitored the food habits of adult bass in separate, 1-acre, bass-bluegill ponds. Adult bass were procured biweekly by angling, and their stomachs were pumped to obtain samples of their food.

A total of 284 largemouth bass were sampled from late May to early September 1974. They had an average length of 11 inches and an average weight of 0.63 pound. A total of 278 smallmouth bass were sampled during the same period. These bass averaged 9.5 inches and 0.39 pound.

Empty stomachs totaled 14 (4.9 percent) for the largemouth bass and 15 (5.4 percent) for the smallmouth bass. Some stomachs contained only a slight trace of well-digested food; these totaled 31 for the largemouth and 33 for the smallmouth.

Unidentifiable animal parts were the most frequently found food item in both bass. The most frequently found, recognizable food items in largemouth bass stomachs were dragonfly larvae, bluegill, mayfly larvae, assorted plant matter, and crayfish. In smallmouth bass stomachs the most frequently found, recognizable food items were crayfish, dragonfly larvae, mayfly larvae, assorted plant matter, and bluegill.

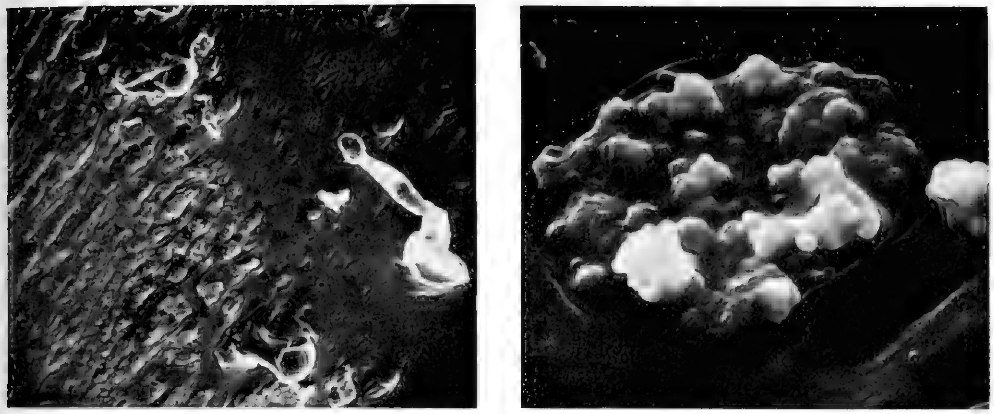
Items making up the greatest volume of food in largemouth bass stomachs were bluegill, dragonfly larvae, assorted animal parts, largemouth bass, and mayfly larvae. In smallmouth bass stomachs the items of greatest volume were crayfish, dragonfly larvae, bluegill, assorted animal parts, and mayfly larvae.

Although food preferences of both species appeared quite similar, the largemouth bass were found to be much more likely to feed on fishes than were the smallmouth. Fish remains of some kind were found in 51.1 percent of the largemouth bass stomachs which contained food, whereas only 28.1 percent of the smallmouth bass stomachs contained fish. In 39.5 percent of the largemouth bass stomachs fish made up the greatest bulk of the food eaten, while the percentage was only 17.3 for the smallmouth. Largemouth bass were also more cannibalistic than the smallmouth. Largemouth bass were positively identified in 12.2 percent of the largemouth bass stomachs containing food items. Smallmouth bass remains were found in only 1.1 percent of the smallmouth bass stomachs.

This information, along with similar data collected during 1975, will be correlated with total fish production in the ponds to assess the relative efficiencies of these bass species living in identical but separate ponds.

Discovery in Plant-Leaf Chemistry

The outermost layer of plant leaves is composed largely of cutin embedded in wax. The cutin is the backbone and con-



Left, electron micrograph of a tobacco leaf surface. On the right side is the normal leaf surface, and on the left side part of the wax has been removed. Right, electron micrograph of a diterpene aggregate center.

sists of cross-esterified polymerized hydroxy fatty acids. The wax is mainly a mixture of hydrocarbons, alcohols, and esters of a number of compounds. In studies of the deposition and penetration of chemical agents, such as herbicides, air pollutants, and insecticides, it is important to understand the chemistry and physical arrangement of the leaf cuticle. Except for certain generalizations, little is known about the cuticle of plant leaves, and even less is known about the mechanism by which chemicals penetrate the leaf surface.

For many years it was believed that plant damage caused by oxidants, such as ozone, was directly correlated to the opening of leaf stomata (pores in the leaf surface for gaseous exchange); however, more recently it has been found that stomatal openings cannot be correlated with oxidant damage in all cases. Plant physiologist Claus Grunwald, in cooperation with Dr. Sai Chang, a biochemist of the University of Arizona Medical Center, is investigating the differences that might exist between the cuticles of oxidant-sensitive and oxidant-insensitive plants. The tobacco plant, which is quite sensitive to air pollutants, was selected for this study. The surface wax layer, or cuticle, of its leaves is easily removed by washing it for a few seconds with an organic solvent, such as chloroform.

Chemical analysis of the tobacco leaf wax revealed a heretofore unreported polar diterpene, and its exact chemical structure has been identified. Diterpenes can be broadly classified as lipids. This diterpene has not been found in oxidant-resistant plants. In young tobacco leaves the diterpene accounted for almost 50 percent of the total leaf wax, and the young leaves are the most sensitive to ozone damage. Older leaves are less sensitive to oxidant damage, and the waxes of these tissues were very low in the diterpene concentration. Electron microscopic investigations show that the polar diterpene is aggregated and embedded in the nonpolar wax of the leaf cuticle. Grunwald and Chang theorize that the polar diterpene center may be responsible for the oxidant sensitivity of tobacco leaves and the leaves of other plants. However, considerably more study is required to prove this working hypothesis.

New Book on Waterfowl Biology

A 544-page book, *The Ducks, Geese, and Swans of North America,* has recently been published. The book is jointly sponsored and published by the Illinois Natural History Survey and the Wildlife Management Institute, a private conservation foundation. The book covers the identification; population status; breeding, migration, and winter distribution; migration chronology; reproductive capability; life

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history; and food habits of more than 50 species of waterfowl.

The material was prepared by Dr. Frank C. Bellrose with the assistance of Dr. Glen Sanderson and Mrs. Helen Schultz, all of the Illinois Natural History Survey's Wildlife Research Section. Lloyd LeMere, Survey technical illustrator, supervised the preparation of the maps and charts used to illustrate the breeding, migration, and winter distribution and the chronology of fall and spring migration of most of the waterfowl species.

Even though Natural History Survey personnel were deeply involved in producing this book, neither the Survey nor any of its staff members will receive royalties or any sort of monetary compensation from the sale of the book. Profits will be used to help finance the activities of the Wildlife Management Institute. This book has been chosen as the January selection of *Outdoor Life* magazine's book club, and it will soon be available at bookstores. It can also be ordered from the printer, Stackpole Books, Harrisburg, PA.

This book is expected to be the standard reference for waterfowl biology for many years. Its publication should result in improved efficiency in management of the waterfowl resource in Illinois and throughout North America.

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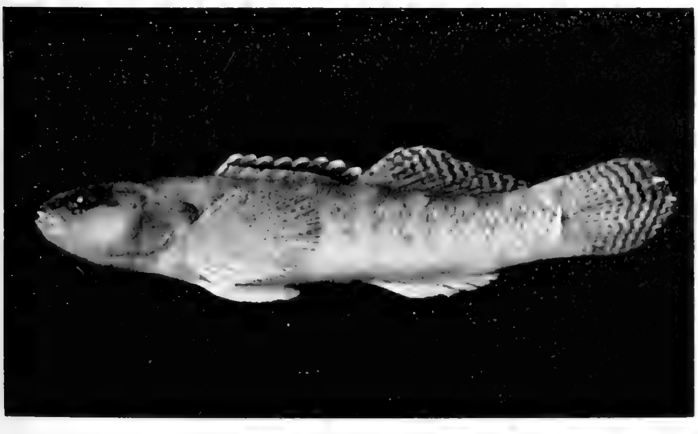
The Stripetail Darter

The stripetail darter (*Etheostoma kennicotti*), a small Illinois fish growing only as large as 65 mm (2.5 inches) in length, was the subject of a life history study recently published by Survey ichthyologist L. M. Page. Copies of this publication, *Biological Notes No. 93,* may be obtained free by writing to the Chief, Illinois Natural History Survey.

The stripetail darter is found only in small rocky streams in the Shawnee Hills of southern Illinois, Kentucky, Tennessee, and small areas of Alabama, Georgia, and Mississippi. Three years of field and laboratory observations were made on a population in Big Creek in Hardin County, Illinois. The stripetail darter was found to occupy slab-rock pools, to live a maximum age of 2.5 years, to grow to a maximum size of about 65 mm, and to feed principally on crustaceans and immature aquatic insects. At one year of age and a minimum size of 30 mm, the stripetail darter spawns in slab pools on the undersides of stones previously selected and guarded by the males as breeding territories. After an elaborate and complex courtship, up to 130 eggs are laid by each female. Several females may spawn with a single male, and nests having as many as 400 eggs were found in Big Creek. After spawning, females leave the nest and the male remains alone to guard the eggs. Eggs hatch in about six days (at 20° C) and the young leave the nest.

Detailed life history studies such as this provide an understanding of the ecological requirements of a species throughout its life, and provide information now much in demand by persons doing environmental studies.

The study on the stripetail darter was the sixth life history study on Illinois darters completed at the Survey. Preliminary investigations presently are under way toward the selection of additional species to be studied. The criteria for selection of



Breeding male stripetail darter from Big Creek in Hardin County, Illinois (photo by Larry Farlow).

a species are a demand for information on the species, the availability of one or more study areas in Illinois, and a population large enough to be sampled at least monthly without depletion. Being considered as subjects are *Etheostoma microperca* in northern Illinois, and *E. proeliare* and *E. chlorosomum* in southern Illinois.

The Heron Problem

Between 1958 and 1964, in the course of his studies on waterfowl populations from aerial censuses, wildlife specialist Frank Bellrose also located and censused heron colonies on the Illinois River between La Salle, Illinois, and Grafton, Illinois, and on the Mississippi River between Alton and Rock Island (Mills et al. 1966). Annual variation in the counts was high, but the data suggested that heron populations might be declining. One problem in assessing the heron counts was the possibility that the birds were relocating their colonies — that apparent declines were merely movements to new locations.

In 1973 wildlife specialists Jean and Richard Graber decided to follow up the important earlier heron counts and extend the study by locating and censusing all of the heron colonies in and adjacent to the State of Illinois. The large colonial herons, great blues and great egrets, nest primarily in bottomland forest, and Illinois, along with its adjacent river boundaries, is particularly rich in this productive habitat. By 1975 much of the best bottomland habitat in this very large study area had been searched from the air or ground, or both. Though further searching will be done, the Grabers believe that they have seen and censused most of the major colonies in the study area, including all of the existing colonies of great blue herons and great egrets on the Mississippi and Illinois rivers.

It is clear that the populations of the large herons are indeed in serious decline in Illinois. The lowest counts of nests provided by Bellrose for the years 1958 through 1964 for the Illinois River Valley included 385 great blue and 375 great egret, whereas the Grabers located 170 great blue and 80 great egret nests for the same area in 1975. The lowest numbers of nests reported by Bellrose for 1958-1964 were 515 great blue and 505 great egret in the Mississippi River Valley, whereas the Grabers in 1975 found only 270 great blues and 115 great egrets in this area.

It is important to have factual evidence of the decline, but it is even more important to understand why. Such understanding depends upon historical perspective, which is not acquired in one or two years of study. The heron problem is an example of one of the most important aspects of the work of the state's scientific Surveys, and that is to tell us where we have been, and, as Lincoln phrased it, "Whither we are tending."

Predicting Fish Populations

The earliest stages in the life of a fish (called larvae) are highly vulnerable to a fluctuating environment, and their survival determines the size of future populations of these fish. Survey aquatic biologists Don Duffor and Ted Storck have been studying the ecology of larval fish in Lake Shelbyville for the past three years. The larval fish are captured with small mesh, conical nets towed through the water from the bow of a boat. Some species are more easily captured than others and the technique is especially useful for the gizzard shad, an important forage fish. Thus far attention has been directed at determining what areas of the reservoir are important for spawning, the interval over which each species spawns, the relationship between spawning success and the future size of the population, and the role fluctuating water plays in governing spawning success.

Lake Shelbyville is an 11,100-acre flood control reservoir in central Illinois and fluctuates substantially in the spring depending on the magnitude of rainfall. Water levels were stable but high in 1973, started low but rose to record high levels in 1974, and remained relatively low throughout the entire 1975 spawning season. The interval over which gizzard shad spawned remained relatively constant from year to year, but specific peaks in spawning in 1974 seemed to be triggered

by rising water. Furthermore, a relationship appears to exist between spring water levels and the number of shad produced. The most shad were captured in 1974, the year of highest water, and by far the fewest were captured in 1975, the year of lowest water. Shad numbers and water level were both intermediate in 1973.

In 1975 the distribution of spawning activity within the reservoir was studied. Sampling was conducted throughout the length of the reservoir and included coves, flooded portions of tributary streams, bays, and midlake stations. The results indicated that spawning activity is most intense at the shallow upper end of the reservoir near the mouth of the major tributary stream. At the lower end of the reservoir significant spawning appeared to be restricted to the inundated floodplains of tributary streams.

The large number of gizzard shad produced in the spring of 1974 were still present in the fall of the year. Yet the following spring this group represented only 2 percent of the total population. This suggests that, at least for shad, the importance of an age group in future years may not be predictable at the larval stage collected by the technique utilized in this study. The correlation between water level and larval shad production suggests that water level manipulation may be a useful management technique to increase spawning success, but this may have little relationship to the resulting adult population.

Other species have not been collected in adequate numbers to establish distribution patterns or relationships between numbers produced and water level. Future efforts will be directed at establishing the location of these species and monitoring their numerical response to environmental conditions. Hopefully the information obtained will provide insight into the factors which govern the success of fish populations, and provide clues for managing reservoirs for maximum fish production.

Crop Pests in 1975

Extension entomologists of the University of Illinois at Urbana-Champaign and the Illinois Natural History Survey held the Twenty-eighth Annual Custom Spray Operators Training School at the University on January 6-8, 1976. Extension entomologist John Wedberg presented a detailed report at this school on the pests affecting crops and other human activities in Illinois during 1975. The information in this report was compiled from reports submitted by County Extension advisers concerning the use and methods of application of insecticides in their counties and from information on file in the Illinois Natural History Survey.

Insect pest problems during 1975 were more severe than during the past few years. Problems varied from soybean thrips and red-headed flea beetles to black cutworms. Potato leafhoppers were numerous throughout the state, and damage to alfalfa was more extensive than in previous years. Alfalfa weevil damage, although severe in some areas, was not as extensive as had been anticipated. Numbers of first-brood European corn borers were generally low, but second-brood numbers reached economic numbers in several areas.

Extension entomologist Don Kuhlman discussed the corn rootworm situation in Illinois. Corn rootworm damage was more severe during 1975 than during 1974. Although it is believed that adverse soil and weather conditions, planting dates, insecticide rate, and tillage practices were major contributors to this situation, the possibility of developing insecticide resistance is being studied.

In 1976 the greatest potential for economic damage in Illinois is north of a line from Pittsfield to Decatur to Danville. Fields planted to corn for two or more consecutive years in the area north of this line may experience moderate to severe damage from northern and western corn rootworms. Farmers who have experienced rootworm damage in past years, and who grow continuous corn, should use a rootworm soil insecticide at planting. Research indicates that corn growers ought to make two corn rootworm counts between August 5 and August 25 in 1976. If these show an average of one or more adult rootworms

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per ear tip, a rootworm insecticide should be applied if the field is to be replanted to corn in the following year.

The most common pests of garden, yard, and home were vegetable and ornamental insects. County Extension advisers each responded to an average of 776 contacts pertaining to insect problems. Of these, 352 were about agricultural insects and 424 were concerned with home, lawn, and garden pests.

An estimated 7,268,590 acres of field crops were treated with insecticides in Illinois during 1975 with a savings from crop loss to farmers of $46,823,220 above treatment costs. Control of soil insects in corn accounts for 65 percent of the estimated profits from the use of insecticides.

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MARCH 1976, NO. 155

Cottontail Population Remains Stable at Allerton Park

Cottontail trapping on the 4-H Area at Allerton Park was conducted in the fall of 1975 for the 20th consecutive year. The data suggest that, except for the years 1962-1965, 1967, and 1971, the rabbit population on the study area has been relatively constant at about 250 individuals, or roughly two rabbits per acre. Survey wildlife specialist Dr. William Edwards has no ready explanation for the low populations during the six years mentioned. Whatever the cause, the factors responsible appear to have been of relatively short duration. This tendency toward stability at Allerton Park is in direct contrast to the declining trend in estimates of abundance and harvest for the statewide cottontail population.

Edwards reports that several tentative conclusions are possible. First, the data suggest that factors regulating the statewide population are largely independent of those regulating cottontails at Allerton Park. In another series of analyses, it was observed that fluctuations in the abundance of the statewide population were closely correlated with agricultural land use. Taken together, these findings suggest that the statewide cottontail population in recent years has had a negative response to the increased intensity of Illinois agriculture, whereas at Allerton, which is not farmed, the rabbit population has showed relative stability.

If an area is left undisturbed, plants will invade bare ground, and over a period of years the kinds of plants will gradually change in a predictable sequence called succession. Because of forestry plantations, numerous heavy, dense stands of multiflora rose, and the maintenance of access trails and fire breaks, no clear picture of the successional relations of the cottontail is emerging from the study. However, it is possible that the species may be adapted to a longer time segment of a successional sere than was previously supposed. (A sere is a series of ecological communities that follow one another in the course of the biologic development of an area.)

There is no strong indication of cyclic tendencies in the data on cottontails at Allerton Park. Whether the cause of this lack of cyclic tendencies is that other factors mask cyclic tendencies or that the species is relatively acyclic at this latitude is not known.

In terms of management and harvest, there appears to be no possibility of a significant increase in the statewide cottontail population under the present intensive,

Common eastern cottontail rabbit photographed at Brownfield Woods near Urbana.

row-crop dominated agriculture. In the management of public lands, it is becoming increasingly evident that an abundance of heavy, dense escape cover is essential to the maintenance of rabbit populations at high levels.

Field Survival of Larvae of an Alfalfa Weevil Parasite

The growing emphasis on biological control in insect pest management demands that scientists acquire knowledge of the basic biology of parasites and predators. Factors preventing the establishment or impairing the performance of artificially introduced enemies of insect pests should be known. In many biological control programs, however, scientists simply do not understand why certain natural enemies succeed or fail in controlling pest insects.

In an effort to control the alfalfa weevil, in 1911 entomologists first released in Utah a small wasp from Europe. This wasp, *Bathyplectes curculionis,* lays its eggs in the bodies of alfalfa weevil larvae, and after the wasp larvae hatch, they feed on the alfalfa weevil larvae. However, the wasp spends about 10 or 11 months of the year as a resting-stage larva in a cocoon in the alfalfa field, where it may be vulnerable to parasites, predators, field cultivation, and insecticides.

As a part of their research directed at creating a pest management program for the alfalfa weevil, Survey entomologists Edward Armbrust and Ronald Cherry conducted experiments between June, 1974, and June, 1975, to determine what factors caused wasp larvae deaths during this seemingly susceptible stage of their development. The entomologists also gathered data on the rate of survival of the wasp larvae.

To carry out this program Armbrust and Cherry collected alfalfa weevil larvae that had been parasitized by the *B. curculionis* wasps. The weevils were held until the wasp larvae had emerged and had enclosed themselves in cocoons.

Cocoons containing live wasp larvae were placed in small cages made of window screen and left open at the top. The cages were placed in a predetermined pattern in alfalfa fields in southern Illinois. The fields were subject to normal cultivation and spraying methods. The cages were observed regularly, and new cages containing wasp cocoons were placed in the fields at about 30-day intervals. At the same time cages with cocoons that had been in the field were returned to the laboratory for inspection.

Cocoons that came back to the laboratory intact were stored for 27 to 28 days at room temperature to determine whether they, in turn, had been attacked by parasites. Then the cocoons were dissected to discover the percentage of larvae still

Wire cage containing field litter and *B. curculionis* cocoons being placed in an alfalfa field.

Intact cocoons (left) of *B. curculionis* and cocoons mutilated by predators (right).

living. In addition, the alfalfa fields were sampled for wasp larvae cocoons in the summer and fall of 1974 and in the spring of 1975 to measure changes in wasp larva populations under natural conditions.

Armbrust and Cherry found that predation by other invertebrates caused more deaths among wasp larvae than did the combined effects of other mortality factors, such as weather, parasites, and insecticide spraying. High heat in the summer may also have been a significant cause of death in the warmer areas of the wasp's range. The overall survivorship of the wasp larva population in the cocoon stage from early summer, 1974, to the next spring was about 16 percent. These findings are the first to show that predators may substantially reduce parasite populations in a field crop. This point deserves careful study in attempts to use biological controls on insect pest species.

The Effect of a Soil-Injected Fungicide on Earthworm Populations

The valuable role played by earthworms in litter decomposition and soil aeration is well established. Any activity of man resulting in the depletion of the earthworm population would, therefore, be considered harmful to the soil ecology. Recent studies in Canada and Europe have indicated that many of our most commonly applied fungicides kill earthworms. In these studies earthworm mortality often approached 100 percent when fungicides were applied directly to the soil.

Bill Black, a graduate student in the Survey's Botany and Plant Pathology Section, studied the effect on earthworm populations of the fungicide benomyl when injected into the soil. Test plots were located at the Survey arboretum near Urbana. Benomyl was selected for this study because it is one of the fungicides most widely used in the United States. Benomyl has the ability to suppress a great number of our most serious plant pathogens, and it has low mammalian toxicity.

The test plots used for this investigation were those used by Dr. Dan Neely, Survey plant pathologist, for his studies on soil-injected benomyl in controlling Dutch elm disease. The plots were treated by pressure-injecting benomyl into the soil in May, 1970, 1971, 1972, 1973, or 1974. The soil of the control plots was not treated with benomyl. To estimate the earthworm populations, Neely and Black poured a solution of formalin onto the soil of each plot, forcing the earthworms onto the soil surface. The number of earthworms to emerge within each plot in 20 minutes was recorded.

In untreated soil the earthworm population increased as the growing season progressed. A substantial reduction of the earthworm population was observed in the most recently treated plot. The average

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number there was 8 worms, compared with 48 in untreated soil. As the time following the benomyl treatment increased, the differences between the numbers of earthworms in treated and untreated soils decreased.

The results obtained from this experiment indicate that the earthworm population is reduced following the soil injection of benomyl. However, at this site near Urbana, the earthworm population returned to normal within a year following the fungicide application and remained at that level thereafter. No long-term reduction in the earthworm population occurred.

Earthworms are only one part of the total soil ecology. The lack of a significant long-term effect on earthworm populations, as shown by this experiment, is by no means proof that benomyl has no long-term effect on the soil ecology. Further studies on other components of the soil ecology will be required before the full effect of soil-injected benomyl is known.

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APRIL 1976, NO. 156

Prehistoric Squirrels

Tree squirrels have been present in North America at least since the Miocene (some 29 million years Before Present). By the Miocene, at least nine genera of sciurids existed, but the place of origin for the species found in early Pleistocene (1 million years B.P.) deposits is not known. Living species may have evolved independently in the Palearctic and Nearctic regions and migrated back and forth from one region to another. A study of prehistoric tree squirrels by wildlife biologists Charles Nixon and Stephen Havera, funded by the Illinois Department of Conservation, is near completion. The remains of squirrels found with remains of prehistoric man or his encampments can tell us something about the ecology of Illinois before the white man's appearance in this area.

By the time of the Wisconsinan ice advance (25,000-15,000 B.P.), both man and squirrels were present in Illinois. The last stage of the Wisconsinan ice advance, the Valders substage, occurred 11,000-5,000 years B.P. The present land forms and drainage patterns in Illinois date from this period. The archaic people were present in southern Illinois, and squirrel remains have been identified from one site contemporary with the Valders period.

Both fox and gray squirrel bones have been identified in the Modoc rock shelter site, located in western Randolph County adjacent to the Mississippi River. Midden material at this site dates from 11,000 years B.P. with occupancy by man extending for 6,000 years until about 4000 B.P. Squirrel remains were found in small numbers throughout the midden. Because squirrel bones were rarely worked into tools or ornaments, it is assumed that the animals were killed locally and not obtained by

Fox squirrel (photo by former Survey photographer W. E. Clark).

barter or transported from more southern tribes.

After the Valders substage retreated, there were several climatic changes that affected forest composition. In north-central Iowa, the sequence was cool-wet (a boreal forest of spruce-fir dated at 11,725 + 200 years B.P.), warmer-dry (transition to a deciduous forest of oak, ash, beech, maple, and birch by 8140 + 200 years B.P.), and warm-dry (oak, hickory, and beginning of grass dominance by 6575 + 200 B.P.). The grasslands spread nearly to the east coast before there was a return to the cool, humid climate of today which favors forest advancement. Squirrels, no doubt, spread northward from their refuge in southern Illinois, Indiana, and Missouri as the forests invaded the prairie peninsula. By this time (5000 B.P.), man was using fire to maintain the boundaries of extant prairies.

If we can assume that habitat requirements of fox and gray squirrels have remained unchanged for the past 10,000 years, ratios of fox squirrels to gray squirrels in these prehistoric middens can tell us something about the habitat surrounding these settlements. Thus the preponderance of fox squirrels found at sites in the counties of Peoria (Kingston site, A.D. 1100-1400) and Will (Fisher site, A.D. 200-1600) would indicate that prairie probably dominated the landscape of north-central Illinois. Gray squirrels predominated in the counties of Crawford (Riverton site, 1600-1169 B.C.), Lawrence (Robeson site, 1600-1169 B.C.), and Rock Island (Crawford farm site, A.D. 1790-1810), indicative of extensive forests with little or no prairie. A mixture of gray and fox squirrels found at sites in the counties of Madison (Cahokia site, A.D. 1200-1550), Randolph (Modoc Cave site, 11,000-5,000 B.P.), and Greene (Apple Creek site, 600 B.C.-A.D. 1200) suggest that a mosaic of prairie and forest occupied these counties. Such general descriptions of habitat for these counties usually concur with those provided by white men when settlement of Illinois began in the early nineteenth century.

Pesticide Study Guide

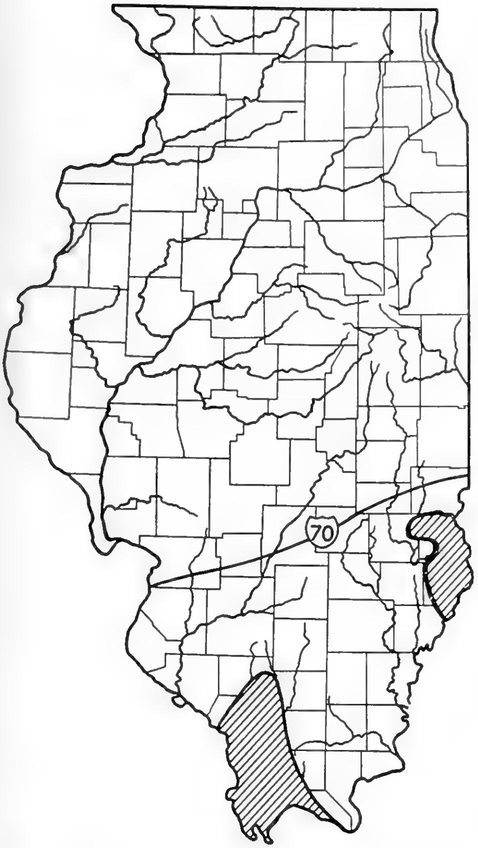
Pesticides play an important role in controlling pests. They protect humans, animals, and plants from diseases, parasites, and predators; prevent damage to buildings; and help increase production of food and fiber. But pesticides should be used only when necessary, and they must be applied wisely, stored safely, and disposed of properly.

Over a 13-year period (1961-1973), 35 people died in Illinois from pesticide poisoning. About 6 percent of the accidental ingestion of hazardous substances (about 664 cases annually) by Illinois children under 12 years of age involves pesticides. Although this is a much lower percentage than for medicine or other hazardous household substances, the important point is that misuse of pesticides does result in accidents. All pesticides should be treated as potential poisons that may endanger some part of our natural environment.

New federal and state laws have been enacted in recent years regulating the sale and use of pesticides and setting standards for their proper labeling, dispensing in the environment, and disposal. A commercial pesticide operator or applicator must now pass a written examination before being issued a license certifying him to purchase or use a restricted-use pesticide.

Stevenson Moore, Survey extension entomologist, and Wayne Bever, Loren Bode, Barry J. Jacobsen, and Marshal D. McGlamery of the University of Illinois College of Agriculture have authored a booklet titled *Illinois Pesticide Applicator Study Guide* (Cooperative Extension Service, Special Publication 39). It can be obtained for the nominal sum of $1.00 by writing to the Extension Entomologist, Room 169, Natural Resources Building, University of Illinois, Urbana, Illinois 61801. This booklet will serve to help prepare a prospective pesticide applicator for certification as a Private Pesticide Operator or as a Commercial Pesticide Applicator or Operator.

In addition to providing the basic information covering various sections of the amended Federal Insecticide, Fungicide,



Map showing the distribution of Brood XXIII of the periodical cicada (prepared by L. J. Stannard and Survey artist Lloyd LeMere).

and Rodenticide Act, the publication contains a glossary of common pesticide terms, a list of poison control centers in Illinois, and directions for obtaining certification. Other chapters deal with such subjects as: the types and toxicity of various pesticide chemicals, symptoms and treatment of pesticide poisoning, safe handling of pesticides, labels and labeling, application equipment and calibration, persistence in the environment, pests and their relatives, and plant diseases and weeds.

Periodical Cicada Time Again

Like tides, death, and taxes, the appearance of our periodical cicadas is certain to occur with ineluctable predictability.

This year Brood XXIII, the Lower Mississippi River Valley Brood of Periodical Cicadas, will emerge from the soil in May and June after 13 years of feeding underground. The adults of this brood were last seen in Illinois in 1963, when they swarmed and sang in enormous numbers, laid eggs in twigs, and then perished. Their eggs hatched, and the young fell to the ground and burrowed down to feed on tree roots for these past 13 years.

According to our records, Brood XXIII will emerge in Illinois south of Interstate 70 with heavy concentrations in the following counties: Alexander, Jackson, Perry, Pulaski, and Union in the southwestern portion of our state; and Crawford, Jasper, Lawrence, and Wabash in the southeastern portion of Illinois.

Because the females lay their eggs in twigs, and in so doing sometimes kill the tips of the twigs, considerable damage can be done by these insects to fruit, nursery, forest, and specimen trees. Roscoe Randell, extension entomologist, recommends that home fruit growers protect their young trees by covering them with cheesecloth. For larger trees, or where many trees are involved, he suggests that sprays of Sevin be applied when the female cicadas are laying their eggs to help reduce damage.

The Survey staff will monitor this brood again to further determine its exact boundaries. Any information, specimens, or reports of singing, damage, and sighting of cast-off skins will be welcomed and gratefully accepted for our records. We have only one chance every 13 years to survey this brood.

Biological Notes No. 91 on the distribution of periodical cicadas in Illinois, authored by Survey entomologist L. J. Stannard, is available free of charge from the Chief, Illinois Natural History Survey, Urbana, Illinois 61801.

Aquatic Life and Ammonia

Ammonia is a common pollutant occurring in Illinois waters and usually results from the decomposition of organic waste such as sewage or waste from animal feedlots. Ammonia-containing effluents are also produced by industrial processes and cleaning operations which use ammonia or

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ammonia salts. Most unpolluted rivers have ammonia concentrations below 0.2 parts per million (ppm) — in contrast, the *average* ammonia concentrations in the upper 100 miles of the Illinois River ranged from 0.6 to 2.6 ppm during the period 1972-1974.

Ammonia places aquatic organisms in double jeopardy because it has both an indirect and direct effect. The bacterial conversion of ammonia to nitrate robs oxygen from the water, thus indirectly affecting organisms which depend on oxygen, and one chemical form of ammonia (un-ionized ammonia) is directly toxic to aquatic organisms. Under conditions of low oxygen, un-ionized ammonia becomes more toxic. The amount of ammonia present in the toxic form is governed by factors such as the hydrogen ion concentration (pH), temperature, and presence of other dissolved chemicals in the water.

Because of the importance of the above modifying factors and because different species of aquatic organisms are apt to have different tolerances for un-ionized ammonia, Survey aquatic biologists Richard E. Sparks, Carl M. Thompson, and Jana G. Waite, in cooperation with several other investigators, are testing the effects of un-ionized ammonia on several species of aquatic organisms common in Illinois, and are using water similar in quality to water in some Illinois streams. The information derived from these experiments is extremely important because ammonia removal is expensive, and any level of waste treatment beyond that which is necessary to protect aquatic organisms represents a waste of economic resources by industries and municipalities.

The research involves seven investigators from five state and federal agencies, and is supported in part by the Illinois Institute for Environmental Studies and by funds provided by the U.S. Department of the Interior, Office of Water Research and Technology, administered by the Water Resources Center of the University of Illinois. Richard Sparks, Carl Thompson, and Kevin B. Anderson, graduate research assistant from Western Illinois University, are measuring the acute, lethal effects of ammonia on bluegill sunfish, fathead minnows, and channel catfish, and ammonia effects on survival, growth, and reproduction of fingernail clams. Physiologist Anthony A. Paparo of Southern Illinois University is assessing the effects of ammonia on the gills of clams, and Jana Waite is measuring the metabolism of clams in response to ammonia.

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MAY 1976, NO. 157

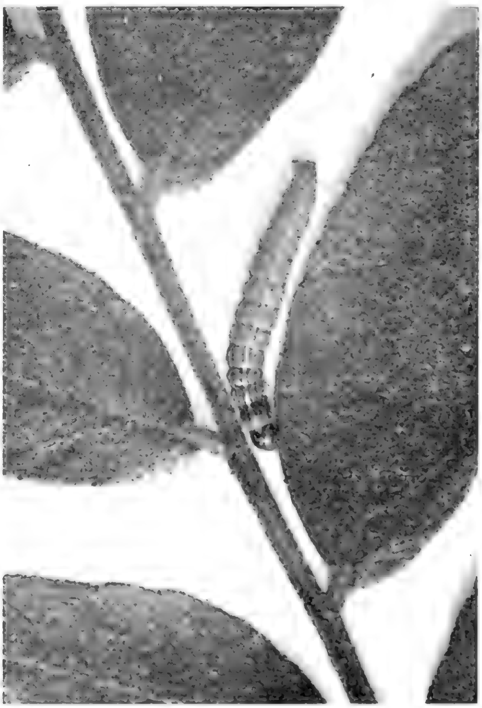
Mimosa Webworm Control

The matted foliage of honey locust and mimosa trees is a common sight from early summer until late fall in eastern and central regions of the United States. The insect responsible for this damage is the mimosa webworm.

The webworm overwinters in the pupal stage in white cocoons on the trunk of the tree or in nearby debris. In late spring the tiny gray moths emerge, and the female moths deposit their eggs on leaves. The eggs hatch, and the small gray-yellow-green larvae begin constructing the characteristic mats of foliage.

According to the results of tests conducted by Survey entomologist Jim Appleby, each of five insecticides applied as foliar sprays in early July gained complete control of the actively feeding larvae. The insecticides tested were diazinon, *Bacillus thuringiensis* (Dipel), acephate (Orthene), carbaryl (Sevimol), and malathion. It is extremely important to control

A mat or nest constructed in honey locust foliage by mimosa webworm larvae.



A mimosa webworm larva and honey locust leaflets.

this insect when the tiny webs are first seen on a tree, as Appleby found that larvae were not killed when insecticides were applied after the larvae had matured and finished feeding.

Appleby further notes that an Indiana researcher, D. L. Schuder, has found that certain honey locust clones are much less susceptible to mimosa webworm attack than are others. The clone Moraine appears considerably less susceptible to attack than Imperial. Unfortunately, Moraine is the preferred host of the honey locust mite, which is responsible for the nearly complete defoliation of that clone during the late summer and fall months. Appleby suggests that Shademaster and Skyline might be better choices of honey locust clones, because both are somewhat resistant to mites and the mimosa webworm.

The Illinois River Valley in Retrospect

Wildlife specialist Frank Bellrose has spent his entire life near the Illinois River, the first 21 years at Ottawa and the next 38 at Havana. During his high school years he canoed on it. Later he covered most of its lakes, making maps of their aquatic and marsh plants. From 1938 until 1946 he censused waterfowl throughout the valley from the shores and by boat. For the next 25 years he used an aircraft to make observations on the abundance of waterfowl.

During his almost 50 years of observing the Illinois River and its adjacent waters, Bellrose has seen many changes. When he lived at Ottawa, there was no fish life in the river, and it smelled like a sewer. The waters were black, with bubbles of fetid gas gurgling to the surface.

The first big change came with the Starved Rock Dam in 1933. In that year other dams were completed at Marseilles, Dresden, and Brandon Roads. The transparency of the water improved, the odor lessened, and fish began to appear. However, parts of the wooded bottomlands of Starved Rock and Buffalo Rock state parks were cleared of trees and inundated.

In the late 1930s Bellrose saw large colonies of nesting herons, large marshes of river bulrush and American lotus, and thousands of acres of stumps marking former bottomland forests. The stumps were a reminder of the increased river level resulting from the diversion of water — through the Chicago Sanitary and Ship Canal — in the early 1900s. This higher river level greatly increased the surface areas of bottomland lakes.

Upon moving to Havana in the spring of 1938, Bellrose became acquainted with levee and drainage districts. About half of the floodplain of the Illinois Valley was leveed and drained between 1900 and 1922. The levee districts removed many important fish and waterfowl habitats from the floodplain. In addition, the levees increased flood heights by several feet on unleveed lands. It seems logical to assume, Bellrose says, that the restriction of waters in the floodplain produced increased rates of sedimentation in the remaining natural waters of the valley.

The closing of the navigation dams at Peoria and La Grange in 1939 also had its effect on the Illinois River. The rise in low water levels of 10 feet at La Grange and 11 feet at Peoria increased the surface area of lakes. Moreover, a reduction in the velocity of the river resulted in accelerated deposition of silt on the bed of Peoria Lake. The increasingly flocculent bottom of the lake resulted in increasing turbidity of the water from wave action. As a consequence, sago pondweed, wild celery, and coontail — aquatic plants that once formed extensive beds in Peoria Lake in years of stable or semistable water levels — disappeared after 1955.

Siltation appears to be increasing in the Illinois Valley. Since World War II the practices responsible for increased sheet erosion are a near doubling of the area devoted to row crops (corn, soybeans), fall plowing of corn and soybean stubble, and a reduction in the land devoted to contour plowing, terraces, and grass waterways.

Bellrose says that it is disheartening to witness the degradation of waters in the

An aerial photograph showing part of Lake Chautauqua, a small section of the Illinois River, and a group of agricultural fields that were leveed off from the river about 1920. Some of these fields were formerly covered by Thompson Lake, once a renowned fishing lake.

floodplain lakes of the Illinois Valley from siltation at a time when urban and industrial pollution is lessening. Since World War II a steady reduction has occurred in the pollution in the upper river from urban and industrial sources, and dissolved oxygen and fish life have increased.

The net result of man's activities in the Illinois Basin is that the fish and wildlife resources have declined as habitat has been destroyed or degraded. Aquatic and marsh plants have almost completely disappeared as a result of increased turbidity and fluctuation in water levels. The loss of plants has reduced food supplies for game fish and waterfowl. In addition, the loss of fingernail clams from many bottomland lakes above Beardstown from a pollutant in 1955 reduced food supplies for diving ducks and some species of fish.

During the 37 years that Bellrose has spent studying waterfowl and aquatic plants in the Illinois Valley, he has reached the conclusion that siltation is the most destructive and insidious form of pollution affecting its quality for wildlife. Only by changing farming practices can any great improvement be accomplished. Fortunately, there are practices that permit high crop yields and still protect the land from severe sheet erosion. The most promising practice is termed minimum tillage. Bellrose says that we need to get farmers to change from the moldboard plow to the chisel plow and its attendant equipment. He hopes that this change will occur before the damage done to the lakes of the Illinois Valley makes their restoration impossible.

Aquazine — New Aquatic Herbicide

Simazine, widely used in Illinois agriculture, was recently approved by the U.S. Environmental Protection Agency (EPA) for use in the control of algae and submersed aquatic plants. It will be distributed as a wettable powder under the trade name Aquazine. Previously, simazine

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had been registered for use in ornamental ponds and in backyard swimming pools.

The control of algae, primarily filamentous algae, frequently has been a difficult task. For many years copper sulfate was the principal chemical agent available for the control of algae. Currently, copper sulfate is the only aquatic herbicide approved by the EPA for use in water intended for human consumption.

Dr. Robert C. Hiltibran, Survey biochemist in the Aquatic Biology Section, and his associates have investigated the effects of simazine in Illinois farm ponds for several years. Simazine, a systemic herbicide, is particularly effective at relatively low rates of application against many of the filamentous algae species commonly found in bodies of water in Illinois and has given from 6 to 8 weeks of control after application. Simazine is also effective against phytoplankton algae and against chara, a higher-branched alga.

Dr. Hiltibran and his associates also found that simazine is effective as an aquatic herbicide in total pond applications, eliminating the stands of some aquatic plants present at the time of application and apparently suppressing the growth of vascular aquatic plants. However, they found that simazine is not effective as a preemergence aquatic herbicide.

Two important water uses are fishing and swimming. Although several effective postemergence aquatic herbicides can be used to control various aquatic plants, their use also requires a suitable delay before using the fishes for food or the water for swimming. Fish from water to which simazine has been applied can be used for food, and the water can be used for swimming immediately after the application. However, the water cannot be used for irrigation or other purposes for 1 year after application. Thus, with the availability of simazine, the pond or pool owner has an additional tool for the control of algae and aquatic plants.

Information concerning the use of simazine can be obtained from Dr. Hiltibran at the Natural History Survey.

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New Alfalfa Weevil Parasites

The most serious pest threatening alfalfa in Illinois is the alfalfa weevil, *Hypera postica* (Gyllenhal). A native of the Old World, this weevil was first discovered in 1904 near Salt Lake City, Utah. For nearly 50 years it remained confined to 12 western states. In 1952 it was discovered in Maryland, and from there it has spread rapidly through the East, South, and Midwest. Since its first appearance in Illinois about ten years ago, it has spread to every county of the state.

In many regions of the state, alfalfa production is almost impossible without some type of weevil control. Although chemical control has been the most widely used method, two other methods are common. One method is to manipulate the timing of the first harvest in the spring. After considering factors such as size of the pest population, plant growth, and prevailing weather conditions, the grower can time the cutting date so that he can achieve the same effect as if he had applied an insecticide.

Adult of the alfalfa weevil (photo by former Survey photographer Wilmer Zehr).

The other method involves biological control agents, such as parasites and predators. One of the most successful biocontrol agents in Illinois is a small parasitic wasp, *Bathyplectes curculionis* (Thomson). This wasp lays its eggs inside young weevil larvae. The wasp larvae develop inside the weevil larvae, and when they have satisfied their needs, they kill their hosts.

Populations of *B. curculionis* have been monitored closely in Illinois for the last three years, and data from these studies indicate that one parasite species cannot sufficiently suppress pest populations. Consequently, in recent weeks and in the weeks to come, additional parasite species have been or will be released in Illinois. Hopefully, through these releases, a better balance will be achieved between pest numbers and beneficial insects.

Bathyplectes anurus (Thomson) is very similar in appearance and behavior to *B. curculionis*. Its distribution has been limited to a few eastern states but recently it has shown some success in Ohio and Kentucky. Research entomologist Dr. Richard Dysart of the USDA-ARS Beneficial Insects Laboratory in Newark, Delaware pro-

vided 795 female and 334 male parasites for release in Illinois. The releases were made in April on the Victor Schubert farm near Coulterville. Mr. Schubert has been cooperating with the Survey for the past three years by providing alfalfa fields for research with alfalfa insects.

Microctonus aethiopoides (Nees) has a fairly limited distribution also and appears to be most successful in northern areas such as lower Michigan and northern Ohio. The female of this wasp attacks adult alfalfa weevils instead of larvae. Eggs are laid in the weevil, and parasite larvae hatch and feed internally until their development is completed. Instead of killing the host, this parasite severely damages host tissue, including the reproductive organs. Consequently, parasitized weevils (females) cannot produce viable eggs. Dr. John Neal, research entomologist, USDA-ARS Field Crops Laboratory, Beltsville, Maryland, provided 251 parasitized adult weevils for release. Release was made in April on the Henry Leithoff farm near Havana. Mr. Leithoff has also been cooperating with the Survey for the past three years.

Release sites will be monitored for the next few years and additional releases made as material becomes available. Given time, a little luck, and continued research efforts, it is the intention of the alfalfa research team to have a complex of parasites and predators actively suppressing alfalfa weevil populations in Illinois to a point where insecticide usage can be greatly reduced in alfalfa production systems.

Pheasants and Inversity

In 1945 the late Paul Errington, one of North America's premier wildlife ecologists, published a classic paper on the population dynamics of gallinaceous game birds. In his paper he set forth a concept that the rate of summer gain among different gallinaceous birds, including the pheasant, tended to be inversely related to the density of adults in the preceding spring. This concept, now commonly termed the principle of "inversity," has had wide application in wildlife ecology during the past 30 years. The principle of inversity relies on the interaction of two density-dependent population mechanisms: the rate of reproduction among the adults and the rate of mortality among the young. The result of the interaction is that spring-to-fall gains are greater for small spring populations of breeders due to increased reproductive rates and decreased juvenile mortality rates, and smaller for large spring populations due to decreased reproductive rates and increased juvenile mortality rates.

Support for inversity among pheasant populations has come principally from extensive population statistics and often from population indices. Intensive studies of the reproductive ecology of pheasants in east-central Illinois by Survey wildlife specialist Ronald F. Labisky, however, does not support the principle of inversity. This Illinois investigation, conducted during the five years 1957-61, revealed that the rate of recruitment of young into the fall population was neither directly nor inversely related to the spring density of hens, but was a static biological parameter. The spring density of hens averaged 77 per square mile; the coefficient of variation was 32 percent. The rate of recruitment of young averaged 333 percent annually; the coefficient of variability of these annual rates was only 5 percent. The correlation coefficient (r) between the abundance of hens in spring and the abundance of young in fall was -0.38 ($P > 0.05$). Thus there was no significant inverse relationship between the spring population of hens and the fall population of young.

Intensive studies of reproductive ecology of pheasants in east-central Wisconsin, published in 1975 by J. M. Gates and J. B. Hale, support Labisky's findings in Illinois. The correlation coefficient (r) between the spring density of hens and the fall density of young for the six years 1959-64 was -0.21 ($P > 0.05$); thus there was no significant indication of inversity in this east-central Wisconsin pheasant population. Interestingly, the rate of recruitment of young in the east-central Wisconsin

population averaged 313 percent annually — very close to the 333 percent statistic for Illinois.

These studies cast doubt that the principle of inversity is applicable to the rate of recruitment of young pheasants. The production of young pheasants does, however, appear to be under density-dependent regulation. The number of young pheasants hatched per hen appears to be inversely related to spring density; but the mortality of young is also inversely related to the number of young hatched per hen. Consequently, these two density-dependent mechanisms oppose rather than complement one another. The trademark of pheasant populations is a relatively fixed rate of recruitment of young; hence, the production of young is a function of the number of hens in spring.

Swine and Fishes

Continuing studies at the Survey field station near Kinmundy, Illinois, represent the first known attempt to adapt certain Asian cultures and techniques to some of our own special environmental problems. The studies are being conducted by aquatic biologists Homer Buck, Dick Baur, and Russell Rose. Important preliminary information was obtained in three-meter diameter pools in 1974, and the work was projected into earth ponds in 1975.

Two ponds (11 and 12) of similar size received nearly identical stockings of fish (4 Asian, 3 native species), but differing amounts of swine manure. Pond 11 received the total wastes from 5 growing pigs (about 39 pigs/hectare of water area); pond 12 received the wastes from 8 pigs (66/ha). Two consecutive lots of pigs were fattened during the experiment. Water levels were lowered approximately 0.5 meter at mid-season to improve natural circulation, but conditions were otherwise static, with no artificial circulation or aeration. Over a growing period of about 170 days (May to October), the net increments in fish biomass were at the rates of 2,971 kg/ha in pond 11, and 3,834 kg/ha in pond 12. The production in pond 12 was particularly impressive because it more than doubled our best previous production, which involved channel catfish fed large quantities of an expensive, high-protein, commercial feed, and because it was achieved with no expenditure of protein beyond that contained in the hog manure. The surprisingly high rates of production were attributed to (1) the high quality of the swine rations; (2) a fortuitous choice of a fish-stocking ratio; (3) an efficient production of plankton algae; and (4) effective water-level management. It was equally impressive that levels of dissolved oxygen were continuously adequate for the survival of the relatively pollution-intolerant largemouth bass.

The apparent success of the system may be attributed to the highly specialized feeding habits of the Asian fishes, including the filter-feeding silver carp, which feeds primarily upon plankton algae, the bighead carp, which filters zooplankton, the grass carp, which utilizes filamentous algae as well as most common aquatic weeds, and the omnivorous common carp, which consumes bottom organisms and most forms of organic detritus, including the fecal material from the associated fishes. When used in the proper numbers and ratios they collectively consume such a large percentage of available organic matter that the water is to a large degree purified. All of these species are fast growing, have a high tolerance for low oxygen levels, and rate from good to excellent as table fare.

The results suggest that the use of these remarkable fishes for the recycling of organic wastes can yield important benefits in such critical areas as pollution control, animal waste management, the conservation of energy, and the production of useful protein. It must be pointed out, however, that the Asian fishes are now restricted for private use in Illinois, as in most American states, and may be used only by recognized research agencies for experimental purposes. Such restrictions are justified because we do not yet know the effects that these exotic fishes might have on certain native fishes, and on certain sections of our aquatic environment.

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Studies on Aquatic Fungi In Illinois

Freshwater hyphomycetes are a very specialized group of fungi that produce asexual spores called conidia. These fungi usually occur on partially decayed, submerged leaves and occasionally on the wood of angiosperms (plants producing seeds enclosed in an ovary). These highly specialized fungi are encountered in most Illinois waters. However, the role they play in the aquatic environment is poorly understood. There is some indication that these organisms predispose submerged leaves for colonization by other aquatic organisms.

The main body of the fungus grows all through the leaf tissue, especially in petioles and veins. The spore-producing parts project into the water, and the conidia develop and are liberated under water. Mature conidia can also be found in the surface foam of most rivers, streams, and lakes in Illinois. The conidia of the majority of these fungi are either tetraradiately branched (having four divergent arms) or sigmoid (wormlike) with the curvature in more than one plane. A special feature of these conidia is that while suspended in water, even over long periods, they do not germinate. However, if they come to rest on a solid surface, germ tubes are produced within a few hours.

Studies on spore growth in aquatic hyphomycetes have clearly shown that the mode of conidium development differs markedly between fungi having either tetraradiate or sigmoid spores and other fungi. Most students of conidial aquatic fungi have considered these differences as fundamental and have suggested some special biological advantage for the tetraradiate and sigmoid conidia over those of a more conventional shape in the aquatic environment. Two explanations have been postulated: first, that the branched or sigmoid conidium may settle slowly in water and hence be carried some distance in a stream before coming to rest; second, that either of these conidial types may act as a minute anchor and have a better chance of becoming caught on a substrate suitable

Scanning electron micrograph of the surface of a maple leaf, illustrating the tetraradiately branched spore of *Tetracladium marchalianum* De Wild., an aquatic hyphomycete.

for the growth of the fungi. Many investigators have observed that aquatic conidia frequently accumulate in the foam which collects behind barriers of twigs or stones below waterfalls and in areas where the water is moving rapidly. Thus, these trapped conidia may be transported great distances with the foam, suggesting that the value of the tetraradiate or sigmoid adaptation may be in dissemination.

Ecological investigations of freshwater hyphomycetes have been limited to substrate, habitat, dispersal, and the role of the fungi in the enhancement of leaf substrates as food for aquatic invertebrates. The most common substrates of these organisms are submerged, decayed leaves, such as those of alders, oaks, elms, maples, chestnuts, brambles, ashes, and willows. Submerged gymnosperm (plants producing naked seeds) leaves are usually totally devoid of aquatic hyphomycetes.

The usual habitat of these fungi is well oxygenated water, such as alpine brooks, mountain streams, and fast-flowing rivers. However, they have also been found in slow-running, often contaminated, rivers; stagnant or temporary pools; melting snow; and soil. Usually, there is an increase in the number of species and individuals of aquatic hyphomycetes from fall until spring, with a decline between April and June.

The usual sampling methods for aquatic hyphomycetes involve the collection of foam samples or partially decayed, submerged angiosperm leaves from most types of freshwater environments. The leaf and foam samples are transported on ice to the laboratory in sterilized bottles and kept under refrigeration until the time of examination. The leaf samples are washed in distilled water. One to three leaves are placed in sterilized petri dishes ½ inch deep, containing pond, river, or lake water that has been sterilized in an autoclave, and the dishes are maintained at room temperature (20°-25° C). Within one to two days the main body and conidia of freshwater hyphomycetes develop. The spore-producing parts and conidia can be observed with a dissecting microscope on any portion of a leaf surface, but are most frequently encountered on petioles and veins.

Grackles Nest On Interstates

While many Illinois bird populations are struggling to survive, certain hardy species are not only surviving, but seem to be benefiting from man's labors. Such is the case of the common grackle (*Quiscalus quiscula*). It is ironic that while human action so often destroys habitat of our most interesting and vulnerable species of birds, we are inadvertently creating habitat for the grackle, a species whose supply seems to be ample.

Grackles have a high tolerance for humans and frequently breed in urban residential habitat, often placing their nests in dense shrubbery 3 to 20 feet high. Landscape architects generally favor mass plantings of shrubs for their interesting displays of flowers, fruits, and foliage, and such plantings have been made along interstate highways. Many such plantings are of thorny species, such as hawthorn and Russian olive, which are attractive to a number of bird species. Grackles prefer spiny thickets as nesting areas and dominate such places along the interstates. Grackles tend to be colonial and can pack many nests into an area of such habitat. They also sometimes prey on the nests of other birds.

Survey wildlife specialists Jean and Richard Graber have seen many colonies of grackles along the Illinois interstates and often wondered how well nests survived in this expanding, noisy habitat. With the discovery in April 1975 of a grackle colony in the median strip of I-57 south of Effingham, the Grabers decided on a short study to learn something about the bird's tolerance for heavy automobile and truck traffic. The 54 nests established there in a Russian olive planting were so close to traffic (7-15 feet) that they were sometimes moved vigorously by the wind of passing vehicles. The noise and exhaust fumes were strongly disagreeable to the human observers, who chose not to remain in the colony more than 2 hours at a time. However, the adult female grackle,

for a successful nesting, had to remain on or at her nest of eggs most of the time through the incubation period of 13-14 days, after which the nestlings were confined to the nest 14-16 days.

Questions asked about the birds in this seemingly hostile environment were: (1) would there be massive desertion of nests, or (2) for any other reason, would hatching or fledgling success be poor? Also of interest was the possibility of lead contamination of the colony from auto emissions, but because the primary emphasis of the study was to be nesting success, no birds were collected. However, through arrangement with Drs. Arnold Hartley, Gary Rolfe, and Raymond Vogel of the University of Illinois Environmental Research Laboratory, lead determinations were made on soil samples from the colony and on eggs that failed to hatch.

For purposes of comparison, a second colony near I-57 was chosen for study. Though similar in size and habitat to the Effingham colony, the second colony, near the Ina exit, was chosen because it was farther from the traffic disturbance, about 215 feet from the edge of the pavement to the nearest nest.

Lead in the soil at different locations in the Effingham colony ranged from 25 to 52 parts per million (ppm) (average 34 ppm) and in the Ina colony from 19 to 22 ppm (average 20 ppm). Lead in eggs from both colonies was below the detectable level. At both colonies adult birds flew away from the highway to forage for themselves and their nestlings; so there was little chance of contamination through food.

The nesting success at the two colonies indicates how tolerant this species is of human traffic. No unusual amount of nest desertion occurred at either colony even during heavy surges of traffic on weekends and on Memorial Day. Clutch size was similar at the two colonies, an average of 4.6 eggs per nest at Effingham and 4.5 per nest at Ina.

A remarkably high percentage of nests produced young — 64 percent (45 percent of eggs) at Effingham and 75 percent (48 percent of eggs) at Ina. By comparison, success (of eggs) was only 8 to 17 percent in different years at a colony studied by other researchers, and success rates for other open-cup nesters (brown thrasher and catbird) in southern Illinois ranged from 29 to 42 percent.

Further study of birds nesting near interstate highways is warranted as a measure of things to come, as unfortunately, the interstate fauna may be the predominant fauna of the future. Now, however, there are far more pressing conservation problems; for example, declining bird populations (herons) and declining habitats (bottomland forest, grassland, and marsh) that deserve priority in studies.

Automated Chemical Analyses

To determine tolerances and environmental requirements of aquatic organisms, the Survey's analytical chemistry laboratory performs analyses to evaluate more than 50 water quality parameters. The instruments in this laboratory are capable of analyzing water samples for principal nutrients, major components of organic and inorganic pollution, and mass ion bal-

Automated system for organic nitrogen analysis.

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ance. To maximize the efficiency of the laboratory staff while maintaining a high level of precision and accuracy, laboratory instruments are automated wherever possible so that large volumes of water-quality data are obtained quickly and easily. In many instances this sophisticated instrumentation includes a computerized printout for rapid calculation and tabulation of data.

The staff members of this laboratory, in addition to working on their own research projects, are able to coordinate water-quality surveillance work for the entire Survey and perform analyses required for ongoing research projects. These research projects include: (1) water quality monitoring in the Lake Shelbyville basin, (2) the monitoring of water quality in the Survey's experimental ponds at Urbana, (3) determining the effects of land use upon water quality, (4) investigating the effects of thermal discharges from a coal-fired generating plant on the water quality of a 2,100-acre reservoir in central Illinois, and (5) studying watersheds to develop meaningful environmental-impact analyses.

One of the areas in which changes in environmental quality can have pronounced effects involves aquatic ecosystems. The close interrelationships between aquatic organisms and the quality of their environment have made these ecosystems the subjects of intensive study by the Survey staff. Recently, Survey scientists began a cooperative multidisciplinary research agreement with the U.S. Department of Agriculture, Soil Conservation Service, to study seven selected watersheds in central and southern Illinois. Water quality and biological studies are necessary for meaningful environmental-impact analysis.

One of the major outcomes of this multidisciplinary cooperative research effort is to be the description of the environmental requirements of aquatic macroinvertebrates, such as midges, crayfish, caddisflies, and stoneflies. Water quality conditions vary in the watersheds under investigation from good to extremely degraded. Staff members will be able to update aquatic invertebrate distribution records within the state, and with the detailed knowledge of over 25 water-quality parameters, including, in many instances, nutrient concentrations, heavy metal levels, dissolved oxygen concentrations, and substrate composition, will begin to quantify the factors governing the distribution and abundance of aquatic macroinvertebrates in Illinois.

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What's In a Name

Every Illinois resident probably has or will have a problem with insects sometime during his or her lifetime. The problem may be simple curiosity about an unusual beetle or caterpillar found in the backyard. Frequently it is related to the destruction of crops, clothing, and forestry products. Diseases, such as encephalitis, remind us that some insects are important medically. One question asked about the suspected insect in nearly all cases is, "What is it?"

The Illinois Natural History Survey employs several persons who are trained to help answer questions of this type. They are the insect taxonomists (not taxidermists) of the Section of Faunistic Surveys and Insect Identification. These specialists identify insects and work closely with the extension entomologists to help diagnose insect problems. Once the problem-causing insect is accurately identified, the need for controlling the pest and the best control measures may be ascertained and the chances of successful control are increased.

There are thousands of different kinds of insects in Illinois. Each insect taxonomist on the Survey staff, by necessity, studies the classification of and identifies only certain insect groups to insure that Illinois residents are provided accurate answers to their questions. One large, common insect group, the butterflies and moths, is studied by George L. Godfrey. Because it is the caterpillars of these insects that create the biggest worry to the general public, Godfrey is continually familiarizing himself with the different kinds of caterpillars.

Police officers occasionally rely on dental characteristics to identify deceased victims of crimes and accidents. Similarly, many kinds of caterpillars are identified on the basis of certain characteristics of their mandibles. Other clues used to help identify caterpillars include color patterns, type of damage caused to a plant, choice of foodplant, and occasionally even odor!

Like other Survey taxonomists, Godfrey's summer laboratory includes the croplands, forested river galleries and prairie sites in Illinois. Using special collecting equipment and lights he does much of his work at night when many moths and caterpillars are most active. Information gathered from

Caterpillar of *Ceriera borealis* (Boisduval) on wild cherry (photo by Survey photographer Larry Farlow).

this work eventually is made available to the public in the form of service identifications, published reports on the classification and life histories of moths, or talks to school groups.

Not all taxonomic research is designed to support control programs directly. Knowing what an animal is not, can be as important as knowing what it is. Therefore, we must learn as much as possible about all insects whether or not they are pests at present. Sometimes the work is useful in conserving and protecting rarer species that are unique to certain ecological areas. Recently Godfrey has been locating small populations of an uncommon and unnamed noctuid moth that feeds exclusively on horse gentian (*Triosteum*). Godfrey is now raising horse gentian in his own back yard with hopes of establishing a colony of the moth so that more can be learned about it.

What Whiteflies See

Whiteflies are small plant-sucking insects. They frequently build up large populations on many field crops, vegetables and ornamental plants. In Illinois they may be found on tomatoes and other plants in home gardens. Whiteflies are most damaging to plants in greenhouses but certain species can be found on field crops such as soybeans.

One of the most common species — the greenhouse whitefly, *Trialeurodes vaporariorum* — was studied by Survey entomologists and a research assistant from India, S. M. Vaishampayan as part of his Ph.D. program at the University of Illinois. This whitefly displays strong attraction to yellow surfaces. Adult whiteflies could be trapped in large numbers on surfaces coated with a sticky substance if the surface transmitted or reflected light in the yellow-green region of the spectrum (520-610 mm).

Since the leaves of most green plants reflect light in that same wavelength it was assumed that whiteflies used visual orientation to find their host-plants. This hypothesis was tested using leaves of different plants sandwiched between layers of transparent glass plates. The whiteflies could "see" the leaf and detect its color but they could not sense the odor of the leaves. Tests were conducted with leaves and bracts of poinsettia — the common Christmas plant. Red or white bracts of poinsettia support the growth of whiteflies just as well as the green leaves. However, when offered a choice of glass-sandwiched leaves and bracts of poinsettia the great majority of the whiteflies were trapped on the green leaves. They responded to the yellow-green light reflected by the leaves. If, a yellow filter backed a white bract, however, the bract would be more attractive than the green leaf, because the "amount" of yellow was greater in this combination of white bract and yellow filter than in the green leaf.

The response of the greenhouse whitefly and many other insects to yellow light may have some practical applications. Special yellow dyes could be mixed with insecticides to assure the contact of the insect with the toxic substance. Researchers have found that certain yellow oils in mixture with pyrethrum sprays almost doubled the effectiveness and persistence of the treatment. The use of yellow traps could also be considered in the detection and control of whiteflies, particularly in greenhouses where they are extremely difficult to control. In this case the yellow traps would be coated with a contact insecticide or simply with a sticky substance. The design and effectiveness of these yellow traps have not been investigated as yet.

Genetic Engineering of Largemouth Bass

Many unique thermal environments have been created by the effluents from electric power generating plants. Since these environments are of recent origin, populations of fish have not yet evolved which can efficiently utilize them. It is not realistic to expect to find natural populations of fish preadapted to these recently created environments. Natural selective processes would probably require thousands of years to produce fish populations well adapted to these distinctive new environments. Consequently, to permit the most

Large-mouth bass (*Micropterus salmoides*) (photo by W. F. Childers).

efficient utilization of these new environments, populations of fish need to be created through genetic engineering.

William F. Childers of the Natural History Survey and Gregory S. Whitt of the University of Illinois are investigating the biochemical genetics of largemouth bass, *Micropterus salmoides*. They are beginning a study of the degree and type of genetic biochemical variation among populations of largemouth bass currently existing in different thermal environments within the United States. New methods for determining biochemical differences between bass populations are proving to be particularly powerful probes in this study.

The separation of specific chemicals in a starch gel medium by use of strong electrical currents is one such method. Starch gel electrophoretic analyses of enzyme variants for enzymes encoded in a total of 25 genetic loci will be used to detect allelic variants associated with specific thermal environments. The investigators will then conduct kinetic analyses of specific purified allelic isozymes to determine the extent that the genetic alteration of these enzymes directly or indirectly contributes to the thermal tolerance of individual bass.

Preliminary data have revealed that a striking north-south clinal distribution exists for two different alleles at the *B* locus of malate dehydrogenase (MDH). The predominance of an enzyme phenotype in a particular thermal environment and the demonstration of its high kinetic efficiency at the corresponding temperatures would be persuasive evidence of the involvement of the enzyme phenotype in controlling the thermal fitness of bass. This thermal kinetic relationship has already been clearly demonstrated for other enzyme systems in other species of fishes. This concept is readily testable and applicable to populations of largemouth bass in thermal lakes.

Once the genetic markers associated with temperature tolerance have been identified and characterized, recommendations will be made indicating the most efficient means of producing populations of largemouth bass which could most efficiently utilize the new thermal habitats.

Waterfowl Power Line Collisions

An unusual opportunity for studying collisions of waterfowl with power lines presented itself in the fall of 1973 when wildlife biologist William L. Anderson and several other Survey personnel initiated a 4-year chemical and biological investigation at the Lake Sangchris-Kincaid Power plant complex. A diked area, called the slag pit, located immediately northeast of the power plant, contains 32 hectares of water surface and is traversed by two high-voltage transmission lines. Large numbers of waterfowl are attracted to the slag pit each autumn and collisions with the power lines are commonplace. Dead and crippled birds are relatively easy to find because they tend to remain in the confines of the slag pit's steep-sided dikes.

A total of 453 waterfowl were found dead or crippled in the slag pit from September to December 1973, 1974, and 1975. Autopsies of 230 of these birds indicated that 75.7 percent (343 birds) had broken wings, lacerations on the anterior of the

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breast or head, or other injuries probably sustained by collisions with the power lines. The remaining birds had been shot, were victims of lead poisoning, or had died of or been injured by undetermined causes.

The 343 waterfowl known to have collided with the power lines, combined with a recovery rate of 57.5 percent for mallards — dead or with broken wings — planted in the slag pit, suggest that about 200 ducks, geese, and coots succumb to the lines at the slag pit between 1 September and 15 December each year. Anderson believes that another 200 waterfowl are lost to the power lines at the three points where the lines cross Lake Sangchris. Thus, mortality of waterfowl due to collisions with power lines at the Lake Sangchris-Kincaid Power Plant complex could total about 400 birds (0.4 percent of the number present at the peak of migration) each fall-winter period.

Anderson recognized five factors that influence the frequency of waterfowl collisions with the power lines at the slag pit. First, the number of birds present was important. A direct correlation existed between the number of birds found dead or crippled and the number present. Second, observations revealed that waterfowl almost never collide with the power lines during daylight hours. Thus, most of the birds found dead or crippled must have collided with the lines during the night time, when weather was adverse, or under other conditions of poor visibility. Third, additional observations implicate disturbance as a factor. Birds startled into flight or otherwise excited frequently hit the lines. Fourth, the species present and their behavior was a factor. The numbers of casualties attributed to the power lines per 1,000 bird-days of use of the slag pit were 0.44 for blue-winged teals and 0.30 for coots, but only 0.03 for mallards and 0.16 for all other species combined. Fifth, Anderson acquired the impression that power-line casualties increased with influxes of new birds, thus, familiarity of birds with the area seems to be a factor.

To minimize losses of waterfowl via collisions with power lines, Anderson recommends that lines not be built over water unless alternate routes do not exist; lines should not cross areas where waterfowl concentrate or are likely to concentrate; visibility of lines in problem areas should be enhanced; and waterfowl should not be disturbed in the immediate vicinity of power lines.

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Hello, World! Bass Number 2 Calling

Radio tracking of largemouth bass in Lake Shelbyville was initiated in July 1975 by aquatic biologists R. Weldon Larimore and Donald W. Dufford. They are studying the effects of fluctuating water levels on largemouth bass movements and habitat preference.

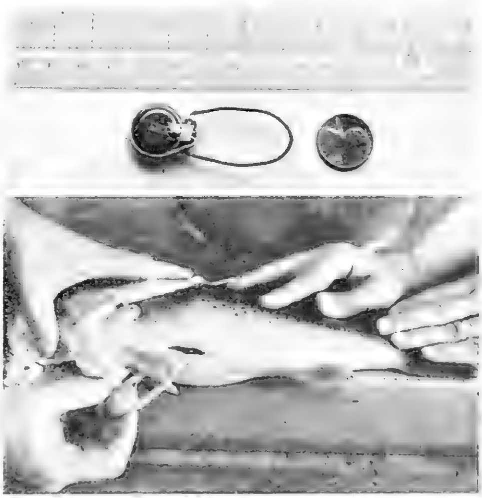
Miniature radio transmitters developed by William Cochran, a Survey wildlife biologist, were surgically implanted in the body cavities of 21 largemouth bass during 1975 and 1976. All of these fish were released at the point of capture following a short recovery period.

Tracking from a boat equipped with a large antenna and a receiver was conducted by Dufford weekly on a Monday-Wednesday-Friday schedule when possible. When a fish was located, its position was determined by triangulation, and the researchers attempted to get as close as possible to the fish to determine habitat characteristics. Location, time, type of habitat, transmitter frequency and pulse rate, estimated depth of the fish, air and water temperature, sky condition, and wind direction and approximate velocity were recorded.

The depth of a fish was determined by comparing the maximum distance at which each signal could be received with known signal attenuation for known depths. The daily minimum distance traveled by each fish was calculated by marking successive locations on a map and measuring the shortest possible distance via water between locations. Range was measured as the minimum distance via water between the two extreme points. The total minimum distance traveled by each fish was the sum of all of the daily minimum distances.

Fish number 2, a 1,165-gram male, traveled a minimum distance of 3,135 meters in 33 minutes when released near the point of capture, or 3.6 times its total length per second for 33 minutes at a water temperature of 25°C. A review of the literature suggested that largemouth bass weighing less than 200 grams should be able to maintain a speed of approximately 2.5 total lengths per second for 25 minutes at 25°C.

The maximum movement was made by a 1,495-gram female that moved a total



(Top) Miniature radio transmitter about 55 mm long, including antenna. (Bottom) Transmitter, covered with protective material, being inserted into the body cavity of an anesthetized largemouth bass. (Photos by John Tranquilli)

minimum distance of 30,478 meters between 28 April 1976 and 21 July 1976 over a maximum range of 16,733 meters. This is an average daily movement of 362.8 meters. The entire maximum range and 22,786 meters of the total minimum distance was traveled from 25 June to 21 July 1976. The average daily movement during this 27-day period was 843.9 meters.

The minimum average daily movement was made by a 1,030-gram male with an average daily movement of 15.0 meters over a 52-day period. The minimum range was covered by a 900-gram female that moved over a range of 221 meters in 31 days before being removed from the lake by a fisherman.

None of the six fish with radios implanted in 1975 was captured by fishermen. Thirteen of the fifteen bass with radios implanted in 1976 were captured by fishermen. Two fish were captured three times each and two fish were captured two times each, making a total of nineteen captures by fishermen. Five of the nineteen captured fish were moved considerable distances by the fishermen and then released. None of these fish showed any indication of homing, or returning to the point of capture. Eight of the nineteen captured fish were released in the same area where captured. Seven of these remained in the immediate area, and one moved a minimum distance of 3,425 meters in a maximum of 20 hours. The remaining six captured fish were removed from the lake by the fishermen. Three of the thirteen released bass died, probably as the result of being hooked by fishermen, 19, 20, and 21 days after being caught. Because so many of these fish have been captured and recaptured, it is clear that the radios do not prevent the fish from feeding or taking anglers' hooks.

Zinc Toxicity Around Smelters

Zinc toxicity is rare in nature and is limited to the vicinities of mines and smelters. Vegetation surveys conducted by wildlife specialist William Edwards in the vicinities of zinc smelters near Sandoval and Beckmeyer, Illinois, suggest that the flora there has been extensively modified directly and indirectly by zinc pollution.

Much of the woody vegetation near the zinc smelters in south-central Illinois appears stunted and twisted. Soils near the plants evidence severe erosion and are increasingly devoid of vegetation as the smelters are approached.

Zinc is an essential constituent of several metaloenzymes and thus is essential to plant growth and metabolism. The zinc requirements of seed plants are in the general range of 0.02 to 0.20 parts per million (ppm).

Other researchers have observed that plants take up zinc from the soil and that the zinc content of plants is affected by zinc levels in the soil. Others have found that zinc toxicity in plants is shown by retardation of growth, sometimes induces iron chlorosis, and affects photosynthesis but not respiration. Zinc in concentrations of 1 to 100 ppm has been found to be moderately toxic to plants.

Edwards notes that it is not possible to understand the implications of zinc pollution on faunal and floral communities without some knowledge of the distribution of that element through the soil profile and, particularly, through the surface soils. Preliminary examination of data on zinc pollution of surface soils in the vicinity of a smelter near Sandoval suggests several points:

Zinc tends to be concentrated in soil materials deposited along streams draining the smelter site. High levels of zinc were found in stream bed deposits as far as 3 miles from the smelter.

High levels of zinc are found in surface soils near the smelter. Zinc concentrations decrease as distance from the smelter increases. No agricultural crops are being grown closer than 300 meters from the smelter complex.

Levels of zinc are considerably lower in agricultural fields than they are in adjacent noncropped areas. This pattern is not fully explainable by the distribution of zinc from the smelter. It is possible that the lower zinc levels in cropland soils reflect the replacement of crop-absorbed zinc by cal-

Sparse, stunted vegetation near a zinc smelter in south-central Illinois. (Photo by Survey photographer Larry Farlow)

cium or other fertilizer elements and, perhaps, the removal of zinc by the crops. Analyses of plant tissues for zinc content should shed some light on this point.

It also appears that on noncropped areas zinc levels are somewhat higher under perennial plants than they are under adjacent annual plants. This difference may reflect the reduced erosion of soils associated with perennial plants. Erosion generally increases as the distance from the smelter decreases.

Edwards plans to continue his investigations to determine to what extent and in what ways zinc concentrations in soils affect plants and wildlife.

Predicting Black Cutworm Development

A number of researchers from such widely separated parts of the world as the USSR, Israel, Canada, Japan, and elsewhere have reported on the biology and development of the black cutworm, *Agrotis ipsilon* (Hufnagel). This insect does a great deal of damage to corn in the United States. However, little is known about its early season occurrence, and no criteria are available for predicting rates of infestation and damage. Survey economic entomologists W. H. Luckmann, J. T. Shaw, D. W. Sherrod, and W. G. Ruesink conducted experiments to determine the rate of development and the developmental threshold of the black cutworm. They then compared and combined their data with data previously published to calculate temperature guidelines that would be useful in predicting the field development of this pest.

The entomologists gathered eggs newly laid by black cutworm adults that had been collected in fields near Urbana-Champaign. The eggs were individually placed in containers of pinto-bean diet and were incubated in controlled environmental cabinets at 18.3°, 21.1°, 23.9°, 26.7°, and 29.4° C. When the eggs hatched, each newly emerged larva was placed in a diet cup and incubated at the same temperature as that at which the egg had

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been incubated. Daily records of growth and development were obtained for each larva.

These data were brought together, and the cumulative number of days required for 50 percent of each black cutworm group to reach a given developmental stage was determined for each temperature. The black cutworm goes through six (and occasionally seven) molt stages and a pupa stage before the adult insect emerges. Using these data, the entomologists determined a theoretical developmental threshold temperature for each growth stage. Such a temperature is the minimum temperature at which development from one stage to another occurs. Their calculated average developmental threshold temperature for the black cutworm is 10.4° C.

As a means of presenting their findings in a manner useful to agriculturists, the researchers converted their data to centigrade degree-days. One centigrade degree-day is accumulated when the mean daily temperature is 1 degree above a specified threshold temperature. Using 10.4° C as the developmental threshold, the entomologists computed the number of degree-days required for an individual cutworm to reach a given life stage, and then they determined the range and median number of centigrade degree-days needed for the development of each life stage. In every step along the way, their findings agreed closely with those of other researchers who had published data similar though not as complete.

These data can be used in field prediction and research. A researcher can take field-collected black cutworm larvae and, by determining the number of accumulated degree-days for the collection site, can obtain a good indication of the date of egg laying of the new generation of black cutworms and the dates when each stage of development will be reached.

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Sulfur Licks or Salt Licks?

In a forthcoming book, "The Biogeochemistry of Blue, Snow and Ross' Geese," soon to be released by the Southern Illinois University Press, Carbondale, the authors, Survey wildlife biologist Harold C. Hanson and Robert L. Jones of the University of Illinois Department of Agronomy, have appended a chapter on the relevance of sulfur in the ecosystem. In brief their discussion relates higher productivity of plants and animals (biomass) to relatively higher levels of sulfates in natural environments. Previous experimental research also indicates this relationship, but a close association has never been postulated.

While preparing the sulfur chapter for their book, Hanson and Jones questioned the chemical nature of mineral or salt licks used by deer and other ungulate big game animals. Not too surprisingly, it was found that sulfur or sulfurous odors (hydrogen sulfide) was associated with licks that had been studied and reported in the literature. However, quantitative data on sulfur in licks has never been available. All attention had been focused on the cations, particularly calcium, sodium and phosphorus. But consideration of these cations and the trace elements failed to provide any consistent picture or rationale for the use of licks by big game animals.

Completely overlooked has been the role of inorganic sulfur in providing bacteria, plants, fungi and the bacteria of the rumen of big game animals the necessary element to form the indispensable amino acids — cysteine and methonine. This factor can be better appreciated when it is realized that the total amount of protein leaving the stomach of a deer is one and one-half to three times the amount ingested in the browse. The increment is synthesized by the bacteria of the rumen. If sulfur is in short supply the ungulates will obviously need to eat a larger amount of food to insure that a balanced amino acid mix will be available.

The assessment of the role of sulfur stimulated Hanson and Jones to solicit soil samples from mineral licks of big game on a continent-wide basis. As of November 15, about 180 samples have been received and 100 additional samples are expected. Findings will provide a better understanding of big game population densities and also pro-

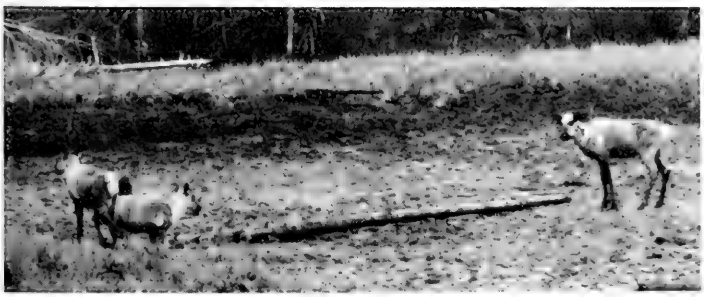

Fig. 1. Mountain caribou at a mineral lick east of Prince George, British Columbia. (Photograph courtesy of K. K. Fugino, British Columbia Department of Recreation and Travel Industry)

vide the basis for the development of an idealized salt block for use on big game ranges as well as for domestic livestock.

A few examples of returns from this continental search are given below in order to indicate the type of response received by Hanson and Jones.

From Quebec: "... in the above two licks mentioned, the odor of rotting eggs (H_2S) is very evident ... there are over fifty known licks in the Matane Preserve — this region, approximately 100-125 square miles, has one of the highest population densities of moose in Quebec."

From Michigan: "For what it's worth, the air around some of the Isle Royale licks smells 'sulfurous'."

From Virginia: "The information contained in your letter explains the observations we have made of the heavy use by deer of sulfur springs here in the mountains."

Cocoons, Parasites, and Insecticides

The alfalfa weevil is the most important alfalfa pest in Illinois. One of the methods of managing populations of this pest is to protect parasites such as *Bathyplectis curculionis* (a wasp which parasitizes the larvae of the alfalfa weevil). In pest control the application of insecticides to alfalfa can affect both the pest and its parasites.

These small hymenopterous parasites spin small sliken cocoons within which the pupal stage is passed, or within which the insect enters into an inactive state called diapause in order to overwinter. Reports in the literature have suggested that application of insecticides in the fall and/or spring have no apparent effect on the diapausing *B. curculionis*.

Survey entomologists D. P. Bartell, J. R. Sanborn, and K. A. Wood have investigated the effects of direct treatment of cocoons of diapausing and nondiapausing *B. curculionis* with several insecticides (carbofuran, methoxychlor, methyl parathion, Imidan and radioactive carbofuran) to determine if cocoons were susceptible to insecticide penetration.

Cocoons of diapausing individuals were impervious to all materials and dosages tested. Cocoons of nondiapausing individuals did not inhibit penetration of lethal dosages of any insecticide or dosage used. This work indicates that insecticides may cause significant mortality of nondiapausing *B. curculionis* individuals in the field and supports the observations that applications of insecticides in the fall or spring does not affect the diapausing individuals. Fortunately, most of the parasites are the diapausing strain, so fall and early spring applications of insecticides have little impact on *B. curculionis*. It has been observed that diapausing individuals require more time to spin their cocoons than do the nondiapausing individuals. The additional spinning time evidently results in a cocoon which effectively inhibits insecticide penetration.

Interesting questions are raised by these results, such as: (1) what influence the physiological state of the parasite has on penetration; (2) how time (newly formed cocoons vs. older cocoons) affects the ability of the cocoon to inhibit insecticide penetration; (3) whether or not the susceptibility of nondiapausing cocoons prevails under field conditions. Questions such as these need to be answered to determine the impact of insecticides on populations of *B. curculionis* and illustrates the importance of intelligent use of insecticides in alfalfa pest management schemes.

Stoneroller Populations

Among the 55 native species of minnows in Illinois there are two superficially similar and often captured together, even in the same seine haul. The taxonomic and distributional status of these two stonerollers, so-called because of their habit of turning stones while scraping off algae for food, was the subject of a study recently published in a technical journal by Survey ichthyologists B. M. Burr and P. W. Smith. Copies of this publication may be obtained free by writing to the Chief, Illinois Natural History Survey.

The largescale stoneroller, *Campostoma oligolepis*, was found to differ from the more abundant common stoneroller, *Campostoma anomalum*, in several important

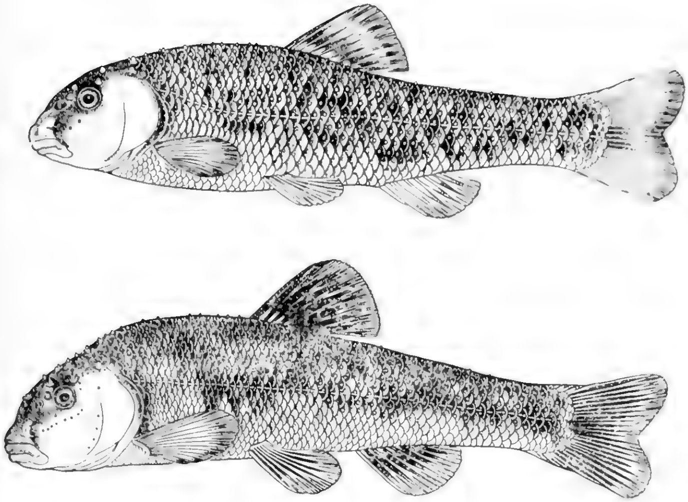

Fig. 2. The largescale stoneroller (upper) and the common stoneroller. (Drawings by Mrs. Alice Ann Prickett)

morphological features. Chief among these were countable characters such as number of scales around the body, number of gill rakers, and differences in breeding coloration and tubercle pattern. Prior to this study, the largescale stoneroller was known only from Wisconsin and the Ozarks of Missouri and Arkansas, but it is now known to occur, or to have once occurred, in parts of Illinois, Iowa, and Minnesota as well. The common stoneroller, on the other hand, is widely distributed in central United States.

Although the two species are often found together, the common stoneroller is by far the more abundant and widespread species in Illinois. However, this has not always been the case. Reidentification of the specimens Stephen A. Forbes and his associates collected prior to 1908 revealed a much wider distribution for the largescale stoneroller than that indicated by a recent ichthyological survey of Illinois. In fact, the largescale stoneroller was often the only species present in the old collections or was by far the more abundant of the two species.

The rather drastic change in the range of this Illinois fish species is similar to what has been found for other fishes in Illinois, Iowa, and Ohio. The decimation of these native populations is presumed to be the result of siltation, general stream deterioration, and also in the case of the largescale stoneroller the construction of reservoirs on rivers where it was formerly common. The largescale stoneroller is still common in the Ozarks where agriculture has had less effect upon streams. The common stoneroller is more ecologically tolerant and is still common in the Illinois streams it once shared with the largescale stoneroller.

Watershed Ecology

During June 1975 the Illinois Natural History Survey began a series of investigations of selected Illinois watersheds as cooperative studies with the U.S. Department of Agriculture, Soil Conservation Service. The purpose of these studies is to provide basic information regarding the aquatic and riparian animals and to determine the physical, chemical, and bacteriological quality of the surface water of each watershed. These data are needed by the Soil Conservation Service for the planning and implementation of water resource development projects. Typical watershed projects include land treatment measures to reduce soil loss by erosion, stream channel improvements, and structural measures such as flood-water retarding structures and multiple-purpose (flood prevention, water supply, and recreation) impoundments. Because of the multidisciplinary nature of

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these studies, a research team from two sections was assembled: L. M. Page, P. W. Smith, and J. D. Unzicker and D. W. Webb of the Section of Faunistic Surveys and Insect Identification and A. R. Brigham and W. U. Brigham (Project Coordinator) of the Section of Aquatic Biology.

Work has been completed on three of the six watershed studies and work is underway on the remaining three of the original study. Results of the faunistic inventory of Bay Creek in southern Illinois indicated a diverse community of invertebrates, fishes, amphibians, and reptiles. An unusual population of the cypress darter, *Etheostoma proeliare,* was discovered in Max Creek, a tributary of Bay Creek and the site of a proposed impoundment. Because of the threatened status of this fish, the Survey recommended additional study to determine the status of this species in Illinois and to examine particularly the utilization of Max Creek by these fishes. Additional funding has been received and this new study is underway. Subsequent sampling in Max Creek has revealed the presence of yet another threatened species, the spring cavefish, *Chologaster agassizi.*

Little Cache Creek and Dutchman Creek, also in southern Illinois, were investigated physically, chemically, and biologically. Water quality was found to be poor, mostly due to the poor quality of wastewater treatment in Vienna. A newly created recreational impoundment in the headwaters of Dutchman Creek, however, was found to be free from pollution. Faunistic investigation did not reveal the presence of threatened or endangered animals which would be affected adversely by the proposed channel improvement project. Rather, it is felt that the proposed modifications would increase significantly habitat diversity and environmental quality and would benefit the aquatic community in the stream.

Since its inception, four additional projects have been added to this cooperative investigation: the study of the cypress darter mentioned above, a fishery and lower vertebrate inventory of Coal and Crane Creeks in west-central Illinois, a faunistic inventory of Sevenmile Creek in southeastern Illinois, and a physical, chemical, and biological inventory of the North Fork of the Embarras River in east-central Illinois. Studies such as these fulfill a principal function of the Survey: The conduct of research in methods of utilizing and preserving the renewable natural resources of Illinois.

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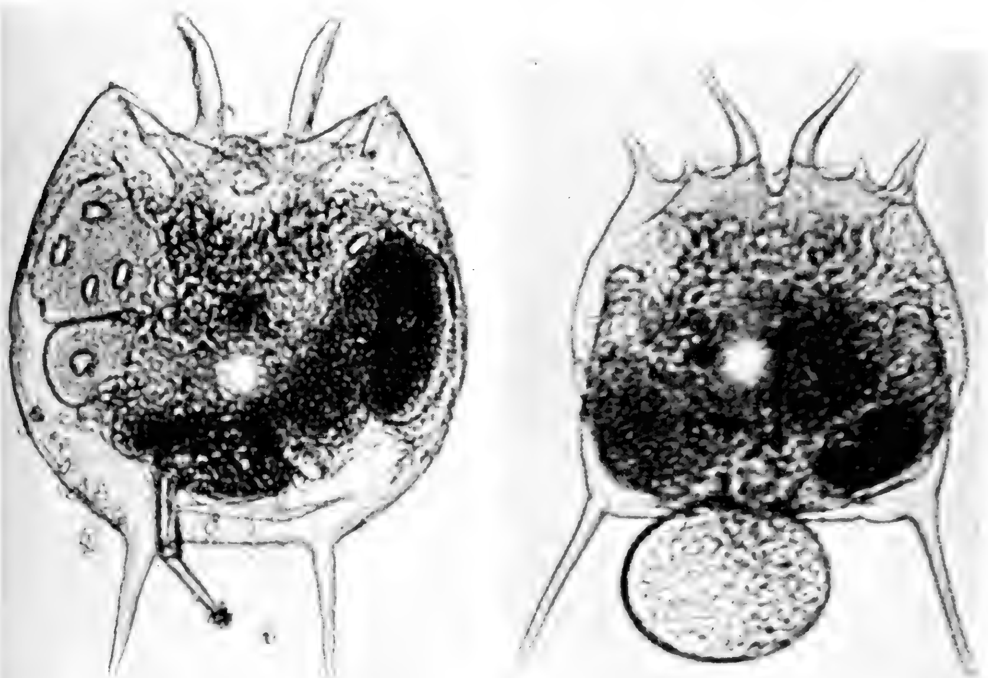
Aquatic Lawnmowers

Since the invention of the microscope, one group of aquatic microorganisms has been the object of study by both amateur and professional biologists. Little known to most people, these creatures, called rotifers, are a major constituent of the freshwater zooplankton, providing an important link in aquatic food chains.

Members of the phylum Rotatoria, rotifers are the single taxonomic category most characteristic of all inland freshwater habitats, yet they have been one of the least studied groups in Illinois lakes and streams. From the arctic to the tropics, these animals are common in the largest lakes and the smallest rain puddles, and, being one of the few groups originating from fresh water, they have become abundant and diversified.

Current studies by Survey invertebrate zoologist Stephen Waite are investigations of (1) the taxonomy of rotifers in central and southern Illinois reservoirs and (2) the importance of these tiny animals as



Two rotifers common to central Illinois reservoirs (left) *Platyias quadricornis* and (right) *Brachionus quadridentatus* with egg. These organisms are about 0.3 mm long, but the majority of rotifer species range from 0.04 mm to 2.5 mm (1/1000 to 1/100 inch).

fish-food organisms in a lake receiving thermal effluents (Lake Sangchris). Ecologically, rotifers function as aquatic grazers (similar to cattle grazing in a pasture); like lawnmowers, they keep the aquatic grasses (algae) mowed and, in turn, provide a substantial energy source for larval fishes. Preliminary data from Lake Sangchris reveal that a substantial rise of fish-food energy in May and June may have been beneficial to larval shad and sunfish, which feed primarily on zooplankters during most of their early life.

Thermal effluents also affect rotifer reproduction in Lake Sangchris. During most of the year, most females produce eggs which develop without fertilization into young females. At certain times, in response to adverse environmental conditions, these eggs develop into females which eventually produce eggs that can be fertilized. Some of these eggs develop into males. Others are fertilized by these males and become resting eggs, which remain dormant for a time before hatching. Some evidence exists of resting egg production during the summer at Lake Sangchris when water temperatures exceeded those of nearby reservoirs.

In addition to studies of the taxonomy and ecology of rotifers, various other phases of their existence present interesting problems for research. All species lack cell reproduction and thus lack the capacity to repair injuries. The processes which determine whether eggs can or cannot be fertilized are still not understood. The ability of rotifers to survive desiccation poses problems in the physiology of reduced metabolism. Some species can survive 3 to 4 years in dry conditions, and when water becomes available, they become active in a few minutes. The development of mechanisms providing resistance to desiccation has permitted some species to become semi-terrestrial, living in mosses, lichens, and tree bark.

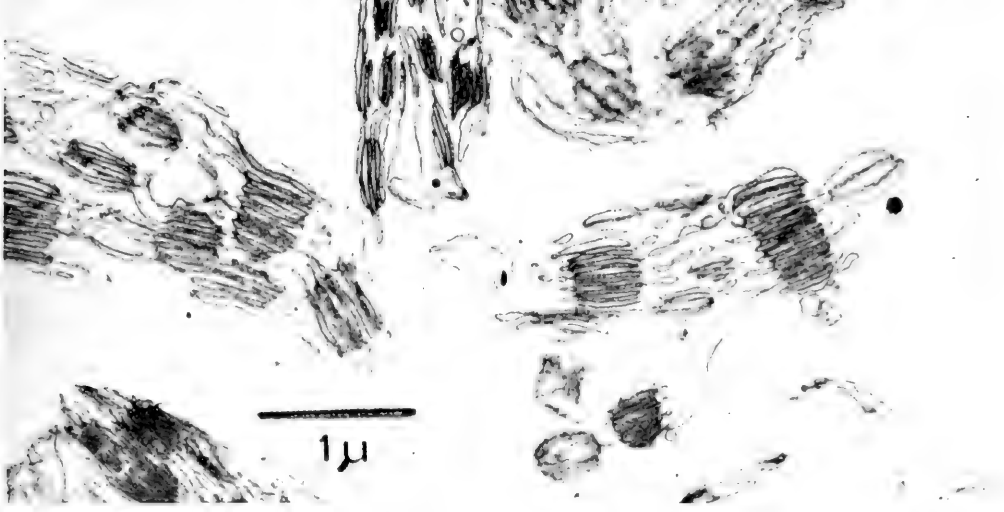
Cell Walls Broken Down By Plant Physiologist

Claus Grunwald, Survey plant physiologist, hasn't been in jail, but he is interested in cells. The cell, often referred to as the building block of plants and animals, is surrounded by a plasma or membrane. This membrane is the living outer boundary of all cells. Plant cells, however, generally have an additional wall outside of the cell membrane which gives support to the cell and the organism. Living cells generally contain a number of organelles, such as chloroplasts and mitochondria, usually also bound by a membrane. Plasma and organelle membranes are not easily seen under the light microscope, but the electron microscope usually reveals a double-layered structure, as shown in the picture. It is generally accepted that the double-layered appearance is caused by a bimolecular layer of lipids sandwiched between two protein layers, and this is referred to simply as the "bimolecular leaflet model."

Basically, plant membranes, like membranes of other organisms, are composed of lipids and proteins; however, exact chemical characterization is often difficult because of contaminating components. Because of the importance of membranes in the bioenergetics and development of plants, plant physiologists in recent years have become interested in the lipid physiology of membranes.

Grunwald has turned his attention to the sterol component of plant membranes. Sterols are classified as lipids and are an important constituent of membranes. Cholesterol is the sterol component of mammalian membranes; however, in plant membranes a number of sterols are found, all closely related in chemical structure to cholesterol. Cholesterol has been found as a membrane component in a number of plant species, but the most commonly found sterols in plant membranes are sitosterol, stigmasterol, and campesterol.

One important function of a membrane is its semipermeability; i.e., it permits the passage of some molecules but not others. It has been found that sterols serve an important function in controlling permeability, and if this lipid component is experimentally removed from membranes, the membranes become leaky. The various plant sterols differ in structure only



Electron micrograph of specially prepared chloroplasts. The membrane structure is clearly visible. The line at the lower left-center represents a micron, equal to one thousandth of a millimeter, or about 0.000039 inch.

slightly, but it has been shown that these small differences have definite effects on membrane behavior.

The qualitative and quantitative sterol makeup of plant membranes is controlled by environmental factors, such as light and photooxidants. Grunwald has studies under way to correlate changes in sterol composition with plant aging as this process is influenced by light intensity and photoperiod.

Flight Characteristics of Ducks

Different species of ducks exhibit different characteristics of flight speed, wing beat, and wing arc. In an effort to discover the underlying reasons for these differences, wildlife specialist Frank Bellrose has been studying the wing conformation and wing load of several species of ducks that have distinctive flight behavior.

The area of the wing surface was obtained by age and sex classes for almost 200 individuals of five species: mallard, black duck, gadwall, wood duck, and canvasback. The weights by age and sex class of many thousands of ducks have been published previously. A comparison of the surface area of the wing with the weight provides data on the wing load. The wing loads for these species are: mallard, 1.49 grams per square centimeter; black duck, 1.31:1; gadwall, 1.35:1; wood duck, 1.23:1; and canvasback, 2.09:1.

Thus, among the five species studied, the wood duck has the lowest wing load and the canvasback, the greatest. The canvasback has the shortest, narrowest wing in this group of species. Field observations indicate that the canvasback flies the fastest and has the most rapid wing stroke. On the other hand, the wood duck is slower than other species but is more adept at quickly altering its line of flight.

A comparison of the length to the breadth of the wing for the five species reveals that wings of all but the canvasback are at least half as wide as they are long. The wing of the canvasback is 42 percent as wide as it is long; the wood duck's wing, at the other extreme, is 56 percent as wide as it is long.

The next step in studying the aerodynamics of waterfowl flight will be to use motion pictures of ducks in flight to determine the wing beat and depth of wing stroke in relation to the wing load and other wing characteristics.

More Knowledge Needed About Insect Pests

According to entomologists Gilbert Waldbauer, University of Illinois, and Marcos Kogan, Illinois Natural History Survey, a great deal of fundamental biological information is still needed about insect pests of agricultural crops. In defending this point of view, the entomol-

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ogists examined bean leaf beetles of the genus *Cerotoma* in relation to the soybean crop and the ecosystem of which the soybean crop is a part.

Studies of the species *Cerotoma trifurcata* are under way at Louisiana State University, the University of Illinois, and the Illinois Natural History Survey, but the most recent comprehensive studies of this insect were published 45 years ago. Waldbauer and Kogan say that this situation is far from unique. "When we look at the literature of almost any pest, we find that our biological knowledge is not sufficient to provide a rational basis for deciding whether pest control is needed or choosing control tactics." They emphasize, however, that in the last few years much research has been done on basic insect biology and on control tactics and strategies.

The entomologists point out that the kinds of information needed about insect pests are (1) complete descriptions of the insect at all stages of development; (2) the host plants that the insect feeds upon or otherwise attacks; (3) biological characteristics, such as in what developmental stage and where the insect overwinters, when and where it lays eggs and how much time elapses between egg laying and hatching, the duration of each developmental stage and where it occurs, and the number of generations of the insect that are hatched in a given geographical region each year; (4) the patterns of the insect's populations and geographical distribution; and (5) the nature of the damage caused by the insect.

Early economic entomologists, Kogan and Waldbauer point out, generally agreed that workable insect controls must be based on a thorough knowledge of the biology of a pest. "This point of view was all but submerged by our reliance on synthetic organic insecticides. These are highly efficient killers of insects — a property which, unfortunately, we confused with efficient control of insect injury to crops.

"We have now come more than full circle and, in espousing the concept of pest management, have recognized that economic entomology is really a form of applied ecology. Obviously, we cannot make rational attempts to manipulate an agroecosystem for our benefit unless we have a thorough and sophisticated knowledge of the organisms in that ecosystem."

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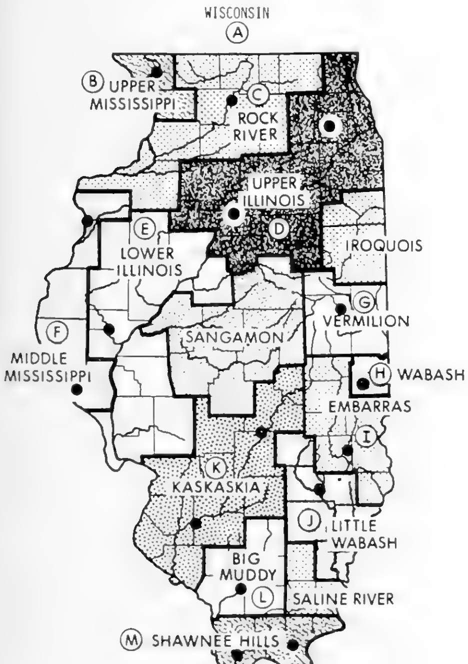
Of Clams and Ducks

The Keokuk Pool is a 46-mile section of the main channel of the Mississippi River which is backed up behind a dam which extends across the Mississippi from Hamilton on the Illinois side to Keokuk on the Iowa side. The Pool hosts the greatest concentration of diving ducks in the Mississippi Flyway during Spring and Fall migrations, and historically has been one of the most productive pools of the entire Upper Mississippi River in terms of game and commercial fishes. The heavy utilization of the Pool by ducks and the high production of fish are both based on an unusual abundance of benthic food organisms, primarily fingernail clams.

Survey aquatic biologists Richard E. Sparks and Carl M. Thompson have been investigating the population dynamics of the benthic organisms since 1973. Their most recent samples, which were taken from a specially-rigged boat in October and November and through the ice in December, show that the fingernail clam populations are only 5-10% of what they were in the Fall and Winter last year. Not only are there fewer clams, but the remaining adult clams are small in size. Utilization of the Pool by diving ducks appears to have declined as a result of the reduction in the population of fingernail clams, upon which the ducks feed. Survey wildlife biologists Frank C. Bellrose and Robert Crompton have censused the waterfowl utilizing the Pool, in conjunction with the weekly aerial census of waterfowl in the state during the Spring and Fall migrations. The peak numbers of canvasbacks and lesser scaup ducks using two major clam beds in the Pool ranged from 212,000 to 244,000 in the period 1973-1975, but declined to 117,000 in 1976.

The low clam populations appear to be related to an extremely low amount of water flowing in the river this year as a consequence of a drought in the Upper



Map showing the geographic areas used for analyses of Illinois populations of gray squirrels. The black dots indicate localities from which most of the specimens were collected within a river drainage.

Mississippi Basin. Since the volume of effluents discharged from cities and industries is relatively constant from year to year, a reduction in river flow results in a reduction in waste dilution. The water quality requirements of fingernail clams are unknown, so that the specific factors responsible for the decline of the clam populations cannot be identified as yet. Richard Sparks and Kevin B. Anderson, a graduate research assistant from Western Illinois University, are currently conducting bioassays with fingernail clams to identify their water quality requirements.

One beneficial effect of the drought, from an aesthetic point of view, is that the Mississippi is considerably clearer this year than it has been for a number of years, because of the reduction of runoff and the amount of sediment entering the river as a result of erosion.

Sparks and Thompson are hopeful that the reduction in fingernail clam populations is a temporary problem which will be alleviated when rainfall in the Upper Mississippi Basin returns to normal levels, and not a persistent problem such as the die-off of fingernail clams which occurred in the Illinois River in 1955. Fingernail clams have failed to recolonize the areas in the Illinois River where they died out, and utilization of the river by diving ducks and the condition factor of bottom-feeding fish have declined as a result.

Gray Squirrels in Illinois

Mammalogists report the presence of two subspecies or races of gray squirrels, the southern subspecies (*Sciurus carolinensis* Gmelin) and the northern subspecies (*S. c. pennsylvanicus* Ord), in Illinois. The northern and southern subspecies of gray squirrels differ in body size and pelage characteristics. The northern subspecies has (1) larger external and cranial dimensions, (2) a whitish-gray winter pelage with clear white patches behind the ears and definite ear tufts, in the northern portion of the range, and (3) a melanistic phase or various degrees of intergradation between gray and black phases often with reddish-brown coloration on the belly. However, controversy exists not only concerning the ranges of these two races of gray squirrels in Illinois, but also if there are enough differences between distant populations of gray squirrels to distinguish them as different subspecies or races.

Wildlife researchers S. P. Havera and C. M. Nixon collected information from over 500 gray squirrel specimens from throughout Illinois in an attempt to define the geographic variation existing among Illinois gray squirrel populations in relation to reference populations of the supposed northern subspecies from Wisconsin and southern subspecies from Kentucky, Tennessee, and Mississippi. Illinois specimens were examined from 12 of the river systems shown in the figure. A series of cranial measurements, an indicator of body size, were used for the multivariate statistical comparison of the various gray squirrel populations. Variations in pelage coloration and some electrophoretic analyses on blood and body tissues were also considered.

The results of the study disclosed significant variations among Illinois gray squirrel populations. Although biochemical differences among selected populations were not detected by electrophoresis, results from pelage and cranial investigations were similar. Instances of melanistic characteristics in pelage coloration were common in Wisconsin (A), and the upper Mississippi (B), Rock River (C), and upper Illinois (D) river basins. The cranial dimensions of the gray squirrels varied somewhat clinally in size from small in the south to large in the north. Northern Illinois gray squirrels from the upper Mississippi (B) and the Rock River (C) areas statistically resemble the northern (*S. c. pennsylvanicus*) reference specimens from southern and central Wisconsin (A). Gray squirrels from the upper Illinois (D) and lower Illinois (E) river systems statistically appear to be intermediate between the group consisting of the northern reference sample (A), the upper Mississippi River (B), and the Rock River (C), and specimens from the remaining Illinois watersheds.

From the results of this study, we believe that the gray squirrels in the upper Mississippi River (B), the Rock River (C), and

Sampling fingernail clams from the bottom of the Mississippi River with a dredge. The muck is strained in the box to the right of the dredge. (Photo by Survey Photographer Larry Farlow.)

the upper Illinois River (D) watersheds are most closely associated genetically with gray squirrels from southern and central Wisconsin (A) designated by taxonomists as the northern subspecies *S. c. pennsylvanicus.* An area of intergradation between the large specimens from the southern part of Illinois apparently occurs in the lower Illinois River drainage (E) and at the northern extremity of the middle Mississippi River (F).

In the central and eastern portions of Illinois, the northern and southern Illinois gray squirrel populations are separated by their scarcity or absence where suitable habitat does not occur in the heavily cultivated prairie areas of the Sangamon, Iroquois, Vermilion, and upper Illinois river systems. Gray squirrels from the remaining Illinois drainages (F-M) more closely resemble the specimens from Kentucky, Tennessee, and Mississippi (N) known as the southern subspecies *S. c. carolinensis.*

The Measure of Diversity

One measure of a community's diversity is simply the number of species it contains. A major problem in ecological research dealing with species diversity of terrestrial soil invertebrates is the lack of accurate sampling techniques. Two basic methods have been used to sample invertebrates which wander freely over the soil surface (cursorial): quadrat sampling and pitfall trapping. Quadrat sampling involves removal of all animals in a given surface area (e.g., one square meter). Pitfall trapping utilizes a container, such as a metal can, which is buried flush with the soil surface and traps animals moving over the ground. Quadrat sampling should provide an absolute density measure, but is influenced by the activity of animals during the brief span of time when the sample is taken. Results are also influenced by the presence of the investigator since many invertebrates are disturbed by his presence and move out of the sampling area. Pitfall trapping provides a continuous sample over time, but is influenced by the activity levels and movements of the animals.

In a recent article Survey entomologist John Unzicker and George Uetz of the Department of Ecology, Ethology and Evolution of the University of Illinois, compared quadrat sampling and pitfall trapping in order to determine the effectiveness of each method. They surveyed the scientific literature for studies of a wide range of communities using both quadrats and pitfalls and used this data in addition to data from two separate

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studies of their own of deciduous forest litter spiders (an Oak-Hickory forest in Illinois and an Oak-Tulip-Maple forest in Delaware) to compare the methods. Assuming that the two methods together sample the total number of species in an area, one can evaluate the estimates made by each method alone. The total number of species taken was compared with the number collected by each method. The pitfall trapping results are highly correlated, whereas the quadrat sampling results show a nonlinear relationship with the total number of species. The quadrat technique adds very few species to a community list beyond those compiled by pitfall trapping alone. In almost all cases there were a larger number of species absent from quadrat samples and present in pitfalls than vice versa. Moreover, quadrat sampling does not sample a constant fraction of species present, but takes a disproportionately larger fraction in more diverse communities. These data suggest that pitfall trapping gives a closer estimate of the total species in a community, and would be more useful in studies of species diversity. Whether or not either method is acceptable for ecological research will depend on the degree of reliability with which it samples the relative abundance of species. Neither of the two methods is without bias in this regard, and it seems that a truly accurate means of assessing relative numbers is yet to be found. Quadrat sampling is an acceptable method for slow moving or nonmotile species in soil and litter, and provides accurate estimates of density. Pitfall trapping is only suitable as a means of sampling cursorial forms, and appears to be the best available at present for this purpose.

Sources of error in pitfall trapping usually can be placed in one of two categories: error resulting from dispersion or placement of traps and error resulting from aspects of trap design. Problems have arisen in previous studies when too many or too few traps are used, and when traps are placed too close or too far apart. Unzicker and Uetz suggest that the particular sampling regime chosen for a study should depend upon the patchiness of the habitat to be sampled, the size of the area, the size of the traps and the type of information being sought. They also describe a pitfall trap which has several advantages over traps used by other investigators. This trap uses a screen roof to exclude debris, has drainage to prevent flooding, uses a removeable funnel to direct organisms into an interchangeable collecting cap, and has a collar which prevents gaps from occurring between the trap and the adjacent soil.

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MARCH [illegible] NO. [illegible]

Sore Stems

Spring is on the way (we hope!). Soon it will be time to start gardens and put in those new trees and shrubs we have been dreaming about all winter. Unfortunately, we must also think about how to control the disease and insect pests that may attack our new plants.

Plant diseases, particularly stem cankers and diebacks, often appear on trees and shrubs following transplanting, when the plants are in a weakened condition due to transplanting "shock." Like humans, plants weakened or under stress may become susceptible to attack by pathogens that may be present in or on a plant but do not cause disease if the plant is vigorous and strong. The many deaths associated with the great flu epidemic early in this century were caused by pneumonia bacteria, normally present in the human body, that only attacked those persons severely weakened by the influenza virus. The same is true with stem canker fungi, which are often present on dead twigs and branch stubs of healthy woody plants.

When trees or shrubs are transplanted, either bare rooted or with a root ball, a considerable portion of the root system is lost. Woody plants often retain as little as half of their original root system after transplanting. This root loss can have many adverse effects on the plant. Food reserves stored in the roots are reduced, open wounds are numerous, and the relative capacity of the plant to take up water and nutrients is reduced. Which of these or other effects is involved in increased disease susceptibility in transplanted plants has not been thoroughly investigated.

To gain some insight into what stress or stresses associated with transplanting influence susceptibility to stem canker fungi, Survey plant pathologists D. F. Schoene-

Stem cankers arising from infected branch stubs on a recently transplanted willow. (Photo by D. F. Schoeneweiss)

weiss and E. G. Wene recently conducted a study on a stem canker disease of European white birch. Container-grown plants were inoculated with a canker fungus known to attack birch weakened by exposure to environmental stresses. The inoculated plants were removed from the containers and approximately half of each root system was removed to simulate root pruning accompanying transplanting. The root-pruned plants were immediately repotted and placed in a growth chamber, where they were kept well watered and under high humidity to prevent water stress. After 2 weeks no infection had occurred. Half of the root-pruned plants plus several inoculated unpruned plants were then subjected to water stress by withholding irrigation until the plants began to wilt. Stem cankers appeared at the inoculation points of all wilted plants.

These results indicate that water stress due to reduced water uptake in transplants is probably the main stress factor involved in increased susceptibility to stem canker fungi.

There are several ways to help prevent water stress in newly planted trees and shrubs. They should be planted in a porous, well drained fertile soil to promote rapid growth of new roots. The soil should be kept moist but not flooded during the first growing season. Top pruning or thinning of branches, if this was not done prior to transplanting, will help reduce water loss and lessen the demand placed on the reduced root system. Keeping trees and shrubs vigorous is the best way to avoid damage caused by stem canker diseases.

Growth of Young Largemouth Bass in Heated Water

Lake Sangchris, located in central Illinois, is a 2,165-acre impoundment used for cooling purposes by Commonwealth Edison's 1,230-megawatt Kincaid Power Plant. The lake consists of three long narrow arms which converge near the dam. The thermal effluent of the power plant is circulated through two of these arms, creating a temperature gradient. The third arm is relatively unaffected by the thermal effluent and serves as a control area for investigations. This rather unusual form makes Lake Sangchris ideal for studying the effects of increased water temperatures upon aquatic organisms.

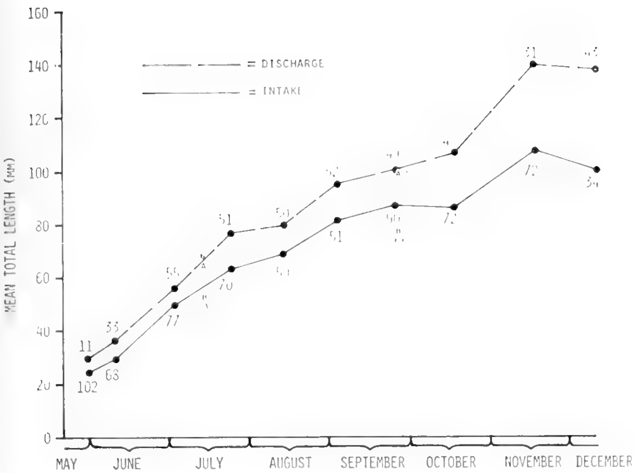
Largemouth bass from Lake Sangchris were studied by aquatic biologist Michael Sule to determine the effects of thermal discharge on the first-year growth of bass. Young-of-the-year bass were collected throughout the 1975 and 1976 growing seasons from the unheated and heated arms of the lake and were analyzed for length, weight, physical condition, and feeding habits. In all collections, bass from the heated arm were larger than bass collected at the same time from the unheated arm of the lake (see figure). The difference in size was probably established by an earlier spawn of bass in the heated arm, giving the warm-water fish a head start on the others.

Growth rates of the two groups were similar throughout most of the growing season, except near the end of the normal growing season, when bass from the heated arm grew somewhat faster than those from the unheated arm. Bass from both arms exhibited similar condition factors.

The feeding habits of bass from the two areas were similar and were determined more by the size of each bass than by its residence in the heated or unheated arm of the lake. Bass changed from a diet of mainly zooplankton to aquatic insects with increase in fish length. As bass reached a total length of about 90 mm, other fish became an increasingly important food resource.

The elevated temperatures of the heated arm seem to have been advantageous to bass inhabiting that area. The extended growing season in that arm allowed more bass to reach a total length that is associated with the more efficient fish-eating habits.

The possible detrimental effects of long-term exposure to elevated temperatures may well outweigh the apparent first-year-growth advantage indicated by this study. Depressed fecundity, higher mortality, and shorter life span are all possible alterations



Growth in length of young-of-the-year largemouth bass collected from the heated (discharge) arm and the unheated (intake) arm of Lake Sangchris, May 29 to December 11, 1975 and in July (small 6A and B13) and September (small A75 and B69) 1976. Each point represents the average length of the fish examined, and the number of fish examined is shown at each point.

which should be considered before any general conclusions are drawn concerning the effects of heated water on largemouth bass.

Pheasants Compete with Prairie Chickens

The greater prairie chicken has been supplanted as a game bird over much of its former range by the ring-necked pheasant. All the north-central states closed their hunting seasons on prairie chickens, at least temporarily, during the first 20 years of this century. The same period saw these states initiate and expand pheasant stocking programs.

In Illinois the remnant flocks of prairie chickens in Jasper, Marion, Clay, Washington, and Wayne counties are now outside the contiguous range of the pheasant. However, a small population of pheasants persists in southwestern Jasper County on and near the prairie chicken sanctuaries. This small population of pheasants probably originated from, and is at least partially maintained by, releases made by local sportsmen.

Survey biologists R. L. Westemeier and D. R. Vance have documented the competition between pheasants and prairie chickens during their studies of the nest ecology of prairie chickens. The competition most often observed by Westemeier and Vance has been the aggressive harassment of prairie chickens on booming grounds by cock pheasants. Although such aggressive behavior has been observed during every month that prairie chickens occupy the booming grounds (late September to June), most harassment apparently occurs in March and April. These 2 months cover the peak booming and breeding season of prairie chickens in Illinois and also the beginning of the establishment of crowing territories by cock pheasants.

No pheasants were seen on booming grounds prior to 1970. During March and April 1970-1976, biologists spent 440 observer-mornings on booming grounds. Pheasants were observed on the grounds on 77 occasions. On 33 of these occasions, some interspecies conflict was noted. In 25 of the 33 encounters between cock pheasants and prairie chickens, the pheasant dominated one or more prairie chickens. Aggressive behavior by cock pheasants usually consisted of chasing one or more prairie chicken cocks off the booming ground. Frequently, the pheasant pursued the prairie chicken in flight. On a few occasions, the cock pheasant performed the courtship display before a hen prairie chicken. In every case, a single cock pheasant was responsible for all harassment.

On the six occasions that prairie chickens proved dominant over a pheasant, the pheasant initiated the conflict with a dominant prairie chicken cock and was chased to the edge of the booming ground by two

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or more prairie chicken cocks. At no time did prairie chickens pursue pheasants off the booming ground.

Evaluating the impact of this harassment by cock pheasants is difficult. However, no benefit to prairie chickens is apparent. Conceivably, such aggression could delay or even prevent successful breeding by prairie chickens on a particular booming ground. At its worst, aggressive behavior by pheasants could result in sterile hybrid offspring, thus reducing the reproductive potential of the largest remnant flock of prairie chickens in Illinois. Pheasant-prairie chicken hybrids have been reported in other states.

In addition to the harassment of prairie chickens on booming grounds by cock pheasants, hen pheasants also interfere with the nesting of hen prairie chickens. Since 1969, pheasants have laid eggs (parasitized) in 17 of a total of 463 prairie chicken nests. Four of these 17 nests were successful. Eleven of the nests were destroyed and two were abandoned (76 percent unsuccessful). In contrast, of the 446 nonparasitized prairie chicken nests, 219 (49 percent) were successful.

No parasitized prairie chicken nests were found prior to 1970. In 1970-1972 one parasitized nest was found each year. Fourteen parasitized nests have been found in the past four years (4 in 1973, 2 in 1974, 4 in 1975, and 4 in 1976). As the number of parasitized nests increases, they constitute a growing proportion (8.9 percent in 1976) of the declining number of prairie chicken nests.

The Survey biologists believe there is cause for concern about this parasitism. The incidence of parasitism is apparently increasing, as is the pheasant population in the area. Parasitized nests are markedly less successful than nonparasitized nests. Consequently, parasitism of prairie chicken nests by hen pheasants has and will probably continue to limit, to some extent, the production of young prairie chickens.

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APRIL 1977, NO. 164

Men, Birds, and Libraries

Recently the Illinois Natural History Survey received, as a gift from Mrs. T. E. (Mary) Musselman, the library and papers of Dr. T. E. Musselman, the renowned Illinois naturalist from Quincy. The papers include his notes on a variety of natural history subjects, but with special emphasis on birds. The notes span 60 years, beginning in 1910, and provide data mainly on western Illinois, particularly Adams County.

The great enthusiasm which Dr. Musselman (he was known far and wide as TE) brought to his studies of natural history, carried through to his lectures, and to the thousands of students who were fortunate enough to hear him and know him. Among that number was the Survey's own Botanist emeritus, Dr. Robert A. Evers, who once worked with TE in evaluating the use of nest boxes by bluebirds. TE took a special interest in the bluebird, when he noticed the once vigorous populations badly depleted. With characteristic energy TE placed thousands of nest boxes along the roads of west-central Illinois, and encouraged similar programs throughout the country. The response was gratifying, as the beautiful birds once again became common in the areas. So successful was the campaign that one who thinks of bluebirds automatically remembers TE. It is an epitaph unlikely to be challenged.

In the past, the Survey has also been the recipient of other historically important papers from Benjamin T. Gault on the birds of Du Page, Cook, and Lake counties, 1884-1927; from John J. Schafer on the birds of Rock Island County, 1913-1931: Frank Smith and his students on the birds of Champaign County, 1903-1923; and Alfred O. Gross on the birds of many counties, 1905-1909.

These papers, individually and collectively, are priceless for the picture they provide of natural habitats and their populations at specific times and localities. From such data and present-day observa-

Dr. T. E. Musselman in his later years. (Photographer unknown)

tions, we can perceive how this part of the world is changing and the rate at which it is changing, important data to have for the conservation of species. Included in the collections of Dr. Musselman and Dr. Gross are photographs which augment the value of the field notes.

All of the notes contain some quantitative data on bird populations, but the field notes of Alfred O. Gross are probably unique in the world as a quantitative record of the habitats and bird life of a large area — perhaps as much as 30,000 acres in Illinois. Some of Dr. Gross' study was repeated in 1956-58 by Wildlife Specialists Jean and Richard Graber, who hope to be able to repeat virtually the entire original census in the next few years.

It is important that the census be repeated as a benchmark to the rates of faunal and habitat changes, particularly as there have been greater changes in the acreage of certain agricultural habitats since 1960 than in the previous fifty years. It also seems important that the censuses be carried out by the Grabers, who benefited directly from the instructions of Dr. Gross on the precise methods of the original census.

Aquatic Ecosystem Model

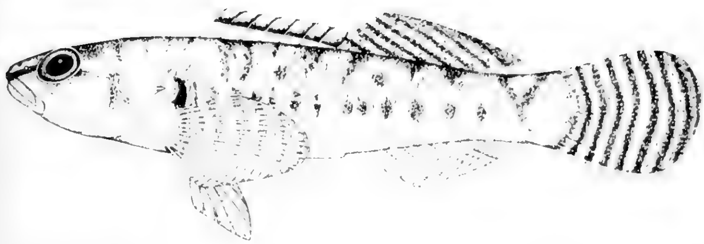
A cooling lake ecosystem model (CLEM) based on studies of Lake Sangchris is being constructed by John McNurney and Don Halffield with the cooperation of the other Survey aquatic biologists. The model will consist of functional submodels describing the physical and biological components of a cooling lake in the littoral and pelagic zones of each of four lake sections. The lake sections include an area directly influenced by the power plant discharge, a transition area, an ambient area of the cooling loop, and an ambient area outside the cooling loop.

A mathematical model is a condensed representation of a real system which uses equations as building blocks. Each equation is the modeler's approximation of a functional relationship existing in the real system in a form which can be conveniently programmed on a computer. While each expression is relatively simple by itself, the combined interactions of all the expressions describing a system can be extremely complex. While a man cannot consider all the aspects of a complex system at once, a modern computer can assimilate a nearly infinite number of equations describing a system, consider all the interactions simultaneously, and produce a summary output in a matter of seconds. The computer simulation of a system's function is limited by the integrity of the model and the cost of its operation. The optimum structure of a model is, therefore, one which represents the system as simply as possible while maintaining the accuracy necessary for reliable operation.

The modeling process begins with identification of the phenomenon to be modeled. The functional relationship of each component part must then be described and defined mathematically. The parameters of each equation must be determined directly by experimentation or indirectly through a literature search. The computerized model is then run under conditions comparable to those of a known real system in a process called validation. The model is refined by adjustment of the descriptive equations and/or parameters until the model results agree with those of the real system.

Preliminary submodels for Lake Sangchris, which consists of original work or modifications of existing models, are completed for water temperature, phytoplankton, zooplankton, periphyton, macrophytes, benthos, and fish. The fish, which are most emphasized in the model because of their recreational value, will be further divided by species and size classes.

Once CLEM has been validated it can be used, by manipulation of input parameters, to estimate the effects of extreme weather conditions or unusual power plant operation on the biota of Lake Sangchris. Proposed management practices could be evaluated in much the same manner. By adjusting certain physical constraints the model could also be used to predict the biological potential of cooling lake sites in the Midwest prior to construction of new power plants.



Adult male stripetail darter, *Etheostoma kennicotti*. In Illinois the species is seldom more than two inches in length.

Stripetail Darters

In 1856 early Illinois naturalist Major Robert Kennicott discovered some specimens of a new kind of small fish in a rocky brook in Union County. His specimens were darters with boldly striped tails somewhat like those of Plymouth rock chickens. The new species was formally described and named *Catonotus kennicotti* in his honor by Frederick Putnam of Harvard University in 1863. Twenty years later a similar but larger stripetail darter was described from the headwaters of the Cumberland River in Kentucky and named *Etheostoma cumberlandicum* by David Starr Jordan and Joseph Swain. During the next 110 years, specimens of the stripetail darter were found in localities geographically intermediate between southern Illinois and eastern Kentucky.

Recently Survey ichthyologists L. M. Page and P. W. Smith studied all available museum specimens of these darters and analyzed variation and distribution among them. In a newly published study, they concluded that specimens from most parts of Kentucky and Tennessee are intermediate in their characters and size attained between the species called *kennicotti* and that called *cumberlandicum*. Since the diagnostic characters of one species grade into those of the other, these workers recommended that use of the name *cumberlandicum* be discontinued and that the earlier name *kennicotti* be applied to all populations of stripetail darters.

The authors were able to show that the stripetail darter originated above Cumberland Falls in eastern Kentucky and dispersed westward to southern Illinois before the last glacial advance. It was able to get into Illinois then because the Ohio River at that time occupied the ancient Cache River channel farther north than it flows at present. The scientists also demonstrated that size attained and general abundance of the various populations are controlled by competition with closely related species. They pointed out that the stripetail darter upstream from Cumberland Falls has no coinhabiting close competitor, and it grows to a larger size and is very common. Elsewhere in Kentucky and Tennessee, the stripetail may occur with as many as three competing relatives, and it is quite rare and dwarfed in size. However, in southern Illinois the Ohio River is presently a barrier to closely related species, and with only one close competitor the stripetail darter is abundant and intermediate in size. This is a classic example of how competition may affect animal species. Since the study was published, evidence has continued to mount that distribution, abundance, and size in this group of darters are strongly influenced by the number of closely related species that occur together in a stream drainage.

Microsporidian Methodology

Microsporidia are an important group of microorganisms which occur as parasites in nearly all major animal groups, but are extremely common in invertebrates such as insects and crustaceans. In 1947 there were about 215 species of microsporidia. Today about 525 species are recognized and another 200 unnamed ones have been reported. This phenomenal growth in the number of microsporidian species, along with a renewed interest in these organisms as biological control agents, prompted the publication of a two volume treatise dealing with the biology of the microsporidia. These are published as volumes 1 and 2 of *Comparative Pathobiology*, a new series

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published by Plenum Press. The treatise, edited by Jiri Vavra of the Czechoslovak Academy of Sciences and Victor Sprague of the University of Maryland, provides a convenient general reference work that will facilitate the efforts of both students and researchers who are pursuing an interest in microsporidia.

One of the chapters in this treatise, "Methods in Microsporidiology," was authored by Jiri Vavra of the Czechoslovak Academy of Sciences and J. V. Maddox of the Illinois Natural History Survey. This chapter covers methods most commonly used by microsporidiologists. In addition to those used for years, more sophisticated techniques are increasingly being employed in these studies. Vavra and Maddox have attempted to compile the methods most commonly used in microsporidian research into a single source. Such topics are covered as making field collections of animals suspected of having microsporidian infections, examining animals for the presence of infections, inducing experimental infections, maintaining infections in cultures of animals, eliminating unwanted infections from animal cultures, and storing viable microsporidian spores. Various physiological, immunological, and cytological techniques are included along with the more commonly used techniques of measuring, staining, and photographing microsporidian spores and developmental forms.

In order to conduct dosage mortality and biological control studies, microsporidian spores must be extracted from infested hosts, purified and quantified. Methods for these operations are discussed. Electron microscopy has become an invaluable tool in studying microsporidia, especially in differentiating the organisms at the species level. Although Vavra and Maddox could not possibly cover all aspects of electron microscopy used, they describe those techniques proved most successful in preparing microsporidia for ultrastructural observation.

In an area of biological research which is developing as rapidly as the field of microsporidiology, old methods are constantly being modified and new methods developed. Consequently, Vavra and Maddox view this chapter on methods as a beginning rather than a conclusion to an accepted methodology within the field of microsporidian research. They hope that the chapter will serve to standardize many of the diverse methods currently being used and acquaint researchers with some innovative methods they have not previously considered using in the fascinating field of microsporidiology.

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MAY 1977, NO. 167

Warning to Farmers: Corn Rootworm Damage May Be Severe in 1977

Entomologists of the Illinois Natural History Survey and the University of Illinois College of Agriculture Cooperative Extension Service are viewing the 1977 corn rootworm situation with deep concern. The unusually large populations of western and northern corn rootworm beetles found in Illinois last August indicate that heavy infestations of corn rootworms may be expected in 1977 in cornfields that were planted in corn last year.

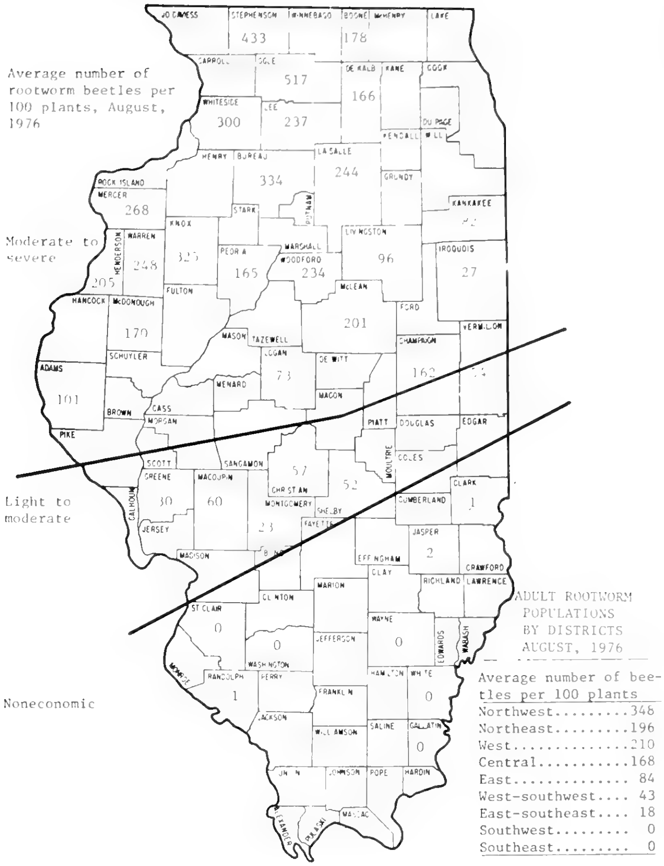
Entomologists D. E. Kuhlman, J. L. Wedberg, J. T. Shaw, and K. Black warn that moderate to severe rootworm damage is expected in many fields of corn following corn in the area north of a line from Pittsfield through Decatur to Danville (see map). Light to moderate damage is expected in fields in south-central counties north of a line from Collinsville to Paris. The potential for rootworm damage south of this line is low.

In a survey made in August 1976, western and northern corn rootworm beetle populations in the northern two-thirds of Illinois were at the highest levels observed during the 10 years that beetle numbers have been monitored. Corn growers in the problem areas should base the decision to use or not use a rootworm soil insecticide on the number of rootworm beetles observed in their fields last year. An average of one or more beetles per plant in August 1976 indicates potential for damage, and a soil insecticide should be used if a field is replanted to corn this year. Lodging or elbowing of corn during July and August are also indicators of rootworm damage. If beetle counts were not made in 1976, corn growers in the moderate to severe rootworm damage areas should plan to use a corn rootworm soil insecticide in 1977.

The large corn rootworm populations in 1976 resulted from the good survival rate of the larvae due to the early corn planting that generally occurred last spring. Western and northern corn rootworm beetles deposit eggs (as many as 1,000 per female; probable average about 400) in the soil at the base of the corn plant or between rows in August and September, and the eggs overwinter in the soil. The eggs begin hatching in early June, and hatching usually takes place over 3 to 5 weeks. Larval and pupal development requires about 1 month. Consequently, all stages of the corn rootworm — egg, larva, pupa, and adult — may be found in a field at one time in early July. Rootworm larvae feed on corn plant roots, and most damage occurs during June and July.

In spite of the severe weather conditions experienced in Illinois during the 1976-1977 winter, preliminary surveys conducted this spring show that most corn rootworm eggs have survived. Thus, a great potential for rootworm damage in 1977 still exists.

In 1976 some corn growers experienced control failures with soil insecticides applied at planting in early to mid-April. It is likely that the insecticides had lost some of their potency by June, when rootworm eggs were hatching, and many of the larvae



Areas of Illinois where corn rootworm damage is expected to be severe, moderate, or noneconomic in 1977. The numbers within some counties are the average numbers of rootworm beetles found per 100 plants in August 1976.

survived to become adults and lay more eggs.

Insect resistance to the organic phosphate and carbamate insecticides in Illinois has not been conclusively demonstrated by research, and resistance does not appear to have been a factor in control failures in 1976. However, the entomologists anticipate that rootworm resistance to soil insecticides may occur within the next few years, since a high percentage of Illinois corn is treated annually with such insecticides. Corn rootworms have already developed resistance to the insecticides aldrin and heptachlor.

In addition to the use of soil insecticides to control corn rootworms, several cultural practices can be employed. Crop rotation is the most effective method of preventing corn rootworm damage. If practical, do not grow corn 2 years in succession in the same field. Select a corn variety that has good standability and root regeneration capability. Finally, plant last those fields that had high rootworm beetle populations in August of last year. Late planting will help to minimize the breakdown of soil insecticides before rootworm eggs begin hatching.

Ridge Lake Research and Fishing

Ridge Lake is a 16-acre lake in Fox Ridge State Park, 7 miles south of Charleston on Illinois Route 130. Dr. George W. Bennett, former head of the Aquatic Biology Section of the Survey, conducted sport fisheries research in this lake from 1941 to 1974. The primary objectives of his research were to devise and evaluate methods of producing optimum fish populations for sport fishermen and to evaluate state fishing regulations pertaining to open seasons, length limits, and creel limits. Dr. Bennett retired in 1974 because of poor health, and

we are sorry to inform our readers of his death on March 18, 1977. His many publications and his book, *Management of Lakes and Ponds,* stand as evidence of the importance of his work. His many colleagues and friends will long remember him not only as a scientist, but also for his warm human understanding of the people he came in contact with.

In 1970 Dr. Bennett initiated a study at Ridge Lake to evaluate the effects of a 14-inch length limit on largemouth bass and channel catfish. He also studied the effects of supplemental feeding on fish production in the lake. This study was terminated in April 1976, when the lake was drained and a complete census of the fish population was made. Data from this 6-year study are now being analyzed, and the results will be submitted for publication during 1977.

Aquatic biologists W. F. Childers and G. W. Lewis have begun a new research program in Ridge Lake. The lake was restocked in May 1976 with adult largemouth bass, adult channel catfish, and fingerling green sunfish x bluegill F_1 hybrids. Public fishing (by permit only) was permitted from June 2 to August 30. During these 3 months fishermen harvested about 55 percent of the adult bass and 13 percent of the channel catfish. The largemouth bass produced a large 1976 brood, and additional 10-inch channel catfish were stocked in the lake during August.

During 1977 public fishing (by permit only) will be permitted from May 21 to August 28. Daily fishing hours will be from 6:00 AM to 10:00 AM and from 3:00 PM to 8:00 PM (Central Daylight Saving Time). The lake will be closed to fishing on Mondays and Tuesdays. No bank fishing will be permitted, but boats are provided free of charge. Fishermen can make boat reservations for the opening days by sending a postcard to Mr. George W. Lewis, Illinois Natural History Survey, 137 Natural Resources Studies Annex, Urbana, Illinois 61801. Fishermen living more than 30 miles from Charleston may fish during both the morning and afternoon fishing periods. Fishermen living less than 30 miles from Charleston may request either the

April 1976 draining census of Ridge Lake fishes. Fish were collected in a weir and were rapidly sorted to keep as many bass and channel catfish as possible alive for restocking the lake.

morning or afternoon session but not both. Fishermen should state their first and second choice for a fishing date. A drawing for reservations for the opening days will be held on May 6, and permits to fish will be mailed to fishermen. After opening day, reservations can be made by writing to the Illinois Natural History Survey, Fox Ridge State Park, Charleston, Illinois 61920, or by calling 217-345-6490 during the daily fishing hours.

The 1977 fishing regulations are:

1. All largemouth bass less than 18 inches total length must be returned to the lake.
2. All channel catfish less than 14 inches total length must be returned to the lake.
3. All hybrid sunfish less than 6 inches total length must be returned to the lake.
4. Each fisherman must have a 1977 Illinois fishing license and must check in with the creel clerk for boat assignment.

Prune Out Dutch Elm Disease

If you are fortunate enough to have one or more healthy elm trees on your property, you will be interested in the results of a research project conducted by plant pathol-

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ogist E. B. Himelick and Evanston municipal arborist D. W. Ceplecha. They found that about two of three Dutch-elm-disease-infected trees can be saved if the infected branches are pruned soon after wilt symptoms become apparent.

In their 4-year study Himelick and Ceplecha worked with personnel of the Evanston Forestry Section, who visually surveyed from the ground the entire city elm population every 2 weeks throughout the growing season. Each elm exhibiting Dutch elm disease leaf-wilt symptoms was tagged, and twig samples were sent to an Illinois Natural History Survey laboratory for confirmation of the presence of the disease.

Most trees that show Dutch elm disease symptoms in early June were infected in the preceding growing season or have been infected through root-graft transmission of the disease. Therefore, trees showing symptoms in early June usually cannot be saved by pruning. In Evanston pruning was begun in the third or fourth week of June. Pruning and painting of the wound were completed within 1 to 5 days after each infected tree on city property was located. Infected trees on private property were reported to the property owners, and most such trees were pruned by commercial tree companies within 1 to 4 weeks after disease detection.

The results show that 62 percent of the infected trees on public land were saved and that 32 percent of the privately owned trees survived.

Himelick and Ceplecha point out that for pruning to be successful, all of the fungus growth must be removed from the tree. A pruning cut must be made far enough below the point of fungus invasion in a branch so that the invasion of other branches and of the trunk will be prevented. Consequently, the researchers' recommendations are that diseased elms be pruned as soon as possible after wilt symptoms appear and that infected branches be trimmed back at least 10 to 15 feet from the point where the sapwood is discolored.

The study further showed that the cost of pruning diseased branches averaged $57 per tree. The cost to Evanston for removing diseased elms on public property was $190 per tree. Another $30 was paid for stump removal, and the cost of planting and maintaining a new tree was $125, bringing the total average cost to $345 per diseased elm. If about 62 percent of the pruned elms survive, the savings clearly justify an intensive scouting and pruning program for any city. The homeowner must also consider the esthetic value of a mature elm versus that of a small replacement tree.

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Glenn, the Moth Man

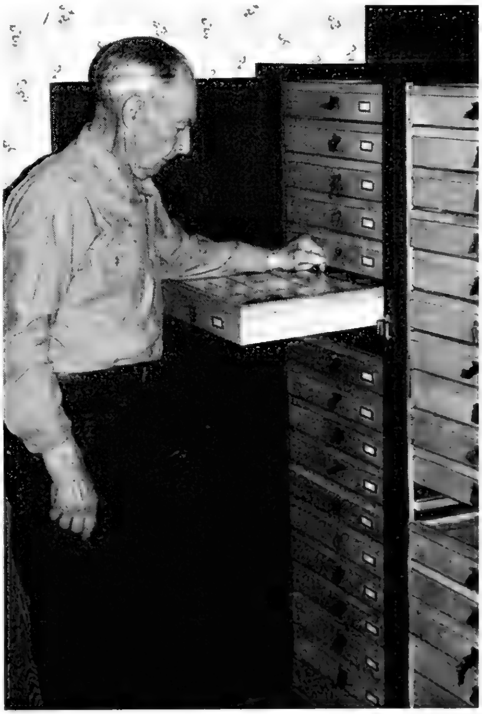
A valuable collection of almost 20,000 specimens, including 1,325 different species of microlepidoptera (small moths) has been presented to the Illinois Natural History Survey. The gift was made recently by Murray O. Glenn of Henry, Illinois, and represents 46 years of work and study in Putnam County.

For its scientific value, the gift is the most important collection of Lepidoptera ever entrusted to the Survey, according to George L. Godfrey of the Section of Faunistic Surveys and Insect Identification.

The collection is virtually a complete record of all the small moths for a defined area of the state and reveals many new host plant associations. Specimens from the Glenn collection have been used by several scientists in the descriptions of 28 new species. Eighteen of these species were originally collected by Glenn in Putnam County, and three were named *glenni* in honor of the collector.

Many of the species represented in the Glenn collection are pests on farm, garden, and fruit crops plus ornamental yard plants. The immediate value of the gift is the aid it will give to the insect identification services offered by the Survey to Illinois residents and various research programs. Accurate recognition of an insect is the first step in determining whether it actually may create a serious problem and how it may be controlled.

The locality, date of collection, and host plant association for all the specimens of each species in the Glenn collection is being recorded for the Survey's permanent files, and the specimens are being incorporated into the Survey's insect collection. Because the new acquisition is so complete, it may prove useful as baseline data for monitoring the effects of a changing environment on animal life in Illinois. Wallace E. La Berge, Survey taxonomist, notes that the collection is extremely valuable because it was started before pesticides were widely used.



Mr. Murray O. Glenn examining some of his extensive collection of moths. (Photo by G. L. Godfrey)

Glenn became interested in collecting insects as a high school student. After graduating in 1911, he studied agriculture at the University of Illinois for three years, but a death in the family made it necessary for him to leave before graduating.

His serious collecting adventures began in 1931. During his "spare" time, Glenn farmed over 600 acres with his brother near Henry in north-central Illinois. After retiring from the farm, he found more time to devote to his avocation. Professional scientists from several universities, the Illinois Natural History Survey, and the Smithsonian Institution soon became aware of Glenn's activities and his collection. They consulted with him professionally many times through the years.

The Survey is delighted to have been selected by Murray Glenn as the institution to care for his extensive collection. This collection is one of the most important acquisitions that the Survey has made during the past 25 years.

Alfalfa Weevil Management

The most serious pest threatening alfalfa in Illinois is the alfalfa weevil. Larvae of the alfalfa weevil feed on alfalfa plants for three or four weeks in the spring. When full grown, they spin silken cocoons on the plants, in fallen or dead leaves, or in the litter on the ground. In one or two weeks adults emerge from the cocoons. In the spring the adults feed for a short time, then fly to protected areas and enter a resting period. In Illinois, most of the adult weevils return to the alfalfa fields in late summer and early fall. Egg-laying by the weevils may be in fall, winter or spring in southern Illinois, but chiefly in the spring in northern alfalfa fields.

Control of the alfalfa weevil depends upon three primary methods. Chemical control with insecticides is the most widely used method. Timing of the first harvest in the spring can be manipulated to help reduce weevil populations and control damage by the weevils. The third method involves biological control agents, such as predators and parasites. One of the most successful biocontrol agents in Illinois is a small parasitic wasp, *Bathyplectes curculionis,* which lays eggs inside young weevil larvae.

The three control methods are interrelated. For example, insecticides kill parasites and predators, as well as alfalfa weevils. Harvesting alfalfa when many weevil larvae are parasitized will reduce the parasite population as well as the weevil population. To help understand how the three methods of control work together, a computer-based mathematical model was developed by Survey entomologists. This model simulated field conditions and analysis of the model, operating under differing conditions and tested by extensive field trials, has resulted in a pest management program for control of alfalfa weevils in Illinois.

Circular 1136 of the Cooperative Extension Service, College of Agriculture, University of Illinois, authored by entomologists John L. Wedberg, W. G. Ruesink, E. J. Armbrust and D. P. Bartell, was published in April, 1977, and is available from County Extension Advisors in Illinois. This circular offers a program which should help in deciding when to spray for alfalfa weevils or whether other control methods are sufficient. The program is a continuing program which will receive further testing, revision, and refinement in the future.

Dr. George W. Bennett

Dr. George W. Bennett, for many years head of the Aquatic Biology Section of the Illinois Natural History Survey, died at 6:30 a.m., Friday, March 18, 1977, in Mercy Hospital, Urbana. He had retired January 1974 after 36 years of outstanding service. He joined the staff in January 1938, and was appointed head of the Aquatic Biology Section in November 1943.

George was trained as a limnologist at the University of Wisconsin, where he received a Ph.D. degree in 1939. Very early in his career he recognized the need and the potential for manipulating the density and composition of fish populations as a means of increasing the yield to anglers. He developed new concepts for the management of his favored combination of largemouth bass and bluegills, and through his

Dr. George W. Bennett. (Photo by Survey Photographer, Larry Farlow)

classic studies of the use of water level manipulations (drawdowns) at Ridge Lake, he achieved new levels of success in fisheries management and influenced an entire generation of fisheries scientists. His more than 30 years of research produced many important scientific publications. Much of his knowledge and philosophy was brought together in his widely used book, "Management of Artificial Lakes and Ponds," first published in 1963, and revised for a second release in 1971.

Perhaps of equal importance to his own research were his contributions as an efficient, kindly, and unselfish administrator. His quiet but effective leadership, exceptional personal qualities, and high standards of achievement were a great source of inspiration to his stag and co-workers, and his warm and gentle personality will not be forgotten by those who had the privilege of knowing George and working with him.

Severe Winter and Pheasants

Illinois pheasants are fortunate because corn and soybeans (the principal food source during winter months) are widely scattered each fall during the harvest. In addition, the pheasant can survive periods of extended fasting and has the ability to recover weight losses rapidly when food intake is resumed. Biologists in the 1940's found no evidence of nutritional stress for the Illinois pheasant, and winter mortality in Illinois was not of the magnitude experienced in northern and plains states, in part because temperature and precipitation patterns were typically milder.

During the past 30 years, intensified corn and soybean production and associated farming practices have resulted in a sharp reduction in the cover commonly used by pheasants in the winter months. Hay and oat stubble fields and grassy areas (principal cover for roosting), woody and shrubby vegetation (used by the ringneck primarily for loafing during mid-day), and corn and soybean stubble (feeding areas) have almost been eliminated in the prime pheasant region of Illinois. At present, nearly all row-crop stubble fields are plowed in the fall, burying a substantial portion of the grain scattered at harvest.

Because of the dramatic changes in land use in Illinois, biologists have renewed their concern over the well-being of pheasant populations during winter. The unusually severe weather conditions experienced in east-central Illinois in December and January 1976-1977 enabled wildlife biologist Richard E. Warner to evaluate the survival of the pheasant population under winter stress.

Severe weather on January 27-29, 1977, including moderate snow, 50 mph wind gusts, and temperatures below −20° F, resulted in severe wind-chill factors. Following this weather, Warner and biologists from the Department of Conservation collected 49 pheasants found frozen in selected areas of study in Ford, McLean, and Iroquois counties. Weights of the 38 hens collected (17 juveniles) averaged 957.5 grams, and the 11 cocks (7 juveniles) averaged 1,293.4 grams. These weights do not represent a significant departure from the normal weights of winter pheasant populations in most midwestern states. Thirty-nine of the 49 collected specimens were found to have

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substantial fat reserves, and 40 had food in their crops. In general, the pheasants were determined to be in good condition up to the time of death, with no evidence of nutritional stress. Nearly all of the specimens were found to have deposits of ice in their throats and beaks, and in some cases the entire head was packed with ice or snow. These are signs that the pheasants succumbed from exposure to extreme winter conditions. Even if shrubby, woody cover had been available, the deaths of some pheasants in the January storm may not have been prevented. The ringneck is associated with protective shrubby and woody vegetation primarily during mid-day hours, feeding occurs in the surrounding plowed or stubble fields, and night roosts are located in the low cover of hay or oat stubble fields and grass. Thus, when severe storms hit during periods of roosting or feeding, the relative inflexibility of the ringneck's behavior works against the bird's well-being. There is no evidence that changes in land use practices in Illinois have created a significant nutrition-related stress for this species.

Some speculation is possible as to the extent and range of the storm-related mortality. The Department of Conservation has received letters describing late January losses of pheasants from individuals located in many portions of Illinois' pheasant range, and biologists in some areas confirm such storm-related mortality. Thus, the effects of the storm appear wide-spread. On one 16-square-mile area, the Ford County Management Unit (FCMU), Warner estimates that perhaps 25 to 50 percent of the pheasants in this area may have succumbed during the January storm. This estimate may be representative of the pheasant mortality occurring in the prime pheasant range. When spring census activities are conducted in May, biologists will be able to define more clearly the effects of this highly unusual winter on pheasant populations in Illinois.

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Studies of Vegetation on Bluffs and Ravines

The land north of Chicago along Lake Michigan rises rapidly, forming high bluffs (40-88 feet) along the lakefront. From Glencoe northward the bluffs and tablelands above them are dissected by more than 30 deep ravines. The lands adjacent to the lake are glacial moraines and are composed of highly erodible glacial till.

Ten large ravine systems occur in Highland Park. This area is largely residential, and several hundred properties could lose structures and land to erosion in the ravines. The city has funded a project with the Natural History Survey to study the vegetation in the ravines and make recommendations on how vegetation can be most effectively used to retard erosion. Drs. Kenneth Robertson and Eugene Himelick, Section of Botany and Plant Pathology, have completed a report, which will be printed and distributed by the city.

The ravines are unique ecological habitats in Illinois and are vestiges of natural areas within a large city. They are heavily wooded and contain an abundance of wild flowers. Most of the plants that occur in the ravines have been identified, including about 50 species of trees, shrubs, and woody vines and about 80 species of herbaceous plants. American beech grows in two of the ravines, the only places in northern Illinois where this species occurs naturally.

The bluffs facing Lake Michigan in Illinois are also subject to severe erosion. The Illinois Coastal Zone Management Program is sponsoring a publication that will help to protect lakefront properties. Part of this publication will explain how to use vegetation for bluff stabilization, and this part is being prepared at the Survey. Dr. Warren U. Brigham, Section of Aquatic Biology, is project coordinator, and Dr. Robertson has written the publication.

The three primary forces causing erosion of the bluffs are direct wave action at the toe, slumping of the crest due to seepage of excess groundwater, and surface water runoff over the slope itself. Vegetation is useful only against runoff, and the toe and crest of a bluff must be made stable by structural means before any attempt is made to establish vegetation on the slopes. (The Army Corps of Engineers and the U.S.D.A. Soil Conservation Service are preparing guidelines on stabilizing the toe and crest.) Most previous work on the use of vegetation for erosion control has been done for slopes along highways and for construction sites. Evidently no experi-

A severely eroded bluff at Lake Forest, Illinois, near the site of the former McCormick estate. (Photo by Dr. Kenneth Robertson)

mental test plots have been used to determine which plants and planting techniques are best suited to bluffs. Dr. Robertson has examined existing vegetation on slopes that are stable. From this work and from a review of the literature on erosion control, he has developed guidelines for the successful establishment of vegetation on unstable slopes.

Robertson found that the paper birch is common in these bluff woods although it is rare in the state. White pine and arborvitae, also rare in Illinois, occur occasionally along the bluff, and buffalo-berry is known in Illinois only from a few sites along the lakefront.

The Natural History Survey and Illinois River Research

"Yes, we did lots of business some seasons, shipping one, two, and three [railroad] cars of chilled and live fish to Eastern markets every week." — "Uncle Billy" LeTissier of Bath, Illinois, interviewed in *The Mason County Democrat* (Havana) August 29, 1941.

The River Research Laboratory of the Illinois Natural History Survey, on Quiver Creek north of Havana, is investigating the effects of the 9-foot barge channel on the Illinois River and its fish, waterfowl, clams, turtles, and other wildlife. Drs. Frank C. Bellrose, wildlife specialist, and Richard E. Sparks, aquatic biologist, are directing the study, paid for by the Chicago District, U.S. Army Corps of Engineers.

These studies build on a long tradition. The Natural History Survey is one of the few agencies in the country which have long-term records of biological changes in major rivers. The first chief of the Survey, Dr. Stephen A. Forbes, established a field station on the Illinois River at Havana in 1894, where studies on the food relationships between the plankton, bottom-dwelling organisms, and fishes were carried out.

Forbes intended that these studies should determine the reasons for the remarkable productivity of the Illinois River and its bottomland lakes so that the river could be managed wisely. After 1900, when the Chicago Sanitary and Ship Canal began to carry sewage and industrial wastes into the upper Illinois River, the purpose of the research was changed. Forbes and Robert Richardson documented the adverse effects of low dissolved-oxygen levels in the water and putrescent conditions in the bottom muds on food organisms and fish. Following Richardson, Dr. D. H. Thompson made extensive surveys of fish populations and their condition.

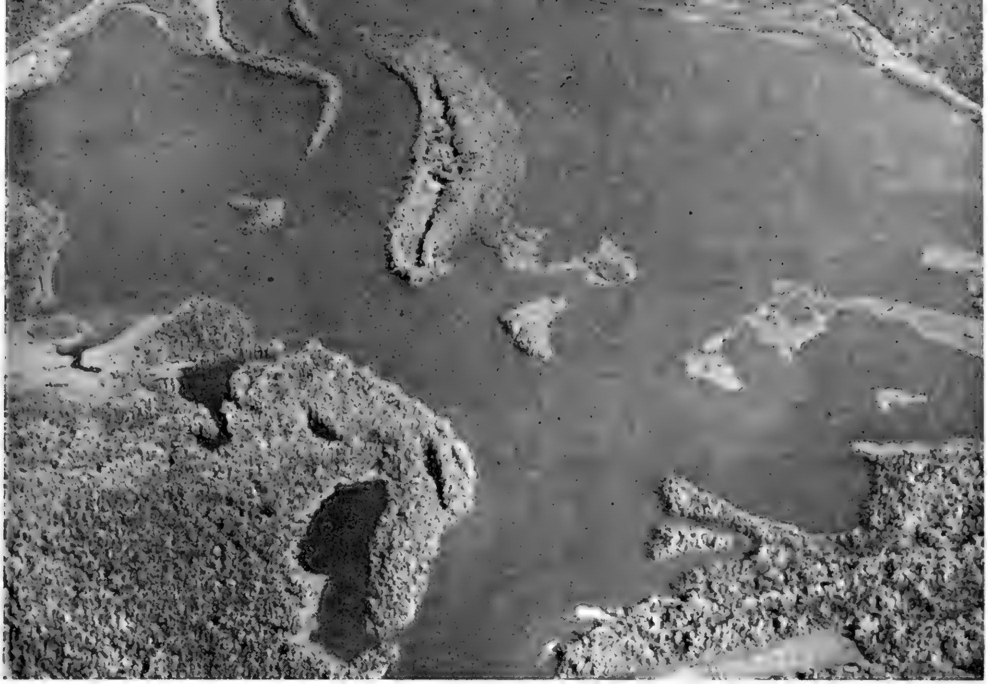
Early in this century, the backwater lakes of the Illinois River achieved national fame as waterfowl hunting areas. Natural History Survey studies of waterfowl habitat and populations in the valley commenced in 1938 with the employment of Dr. Bellrose and Arthur S. Hawkins.

To facilitate their studies, a small building — still in use — was built in 1939 on the Chautauqua National Wildlife Refuge in cooperation with the U.S. Fish and Wildlife Service. Early studies included the ecological requirements of aquatic, marsh, and moist-soil plants; the food habits of waterfowl; and the abundance and migration habits of waterfowl.

In 1949 Dr. William C. Starrett was assigned to the laboratory to investigate the fishes and other aquatic organisms of the river and its bottomland lakes. His fishery investigations filled a gap which had existed since Dr. Thompson had left in 1942. The passing of Dr. Starrett in December 1971 brought a temporary cessation in aquatic research until Dr. Sparks assumed this responsibility in July 1972.

The locks and dams and the 9-foot navigation channel went into operation in the Illinois River in 1938. Since then freight tonnage on the Illinois has increased at least 10 times. Several proposed construction projects — a new lock and dam at Alton, duplicate locks along the river, or a 12-foot channel — would further increase barge traffic on the Illinois. By looking at effects of the existing 9-foot channel and current barge traffic, researchers hope to learn what more traffic might mean for the river, its backwater lakes, and the plants and animals that depend on both.

Valuable old research results gathered in the 1930's and 1940's on Illinois River fishing — long thought to have been lost



The sloughs, backwaters, and bottomland lakes of the Illinois River were once highly productive of fish and wildlife. Now fish and duck food organisms, such as fingernail clams and mayflies, are gone; aquatic vegetation has disappeared; and sloughs like Babbs (on the right) and Big Meadow (left) are rapidly filling with sediment. The main channel of the Illinois River meanders through the left center of the picture. From bluff to bluff the river valley is 2½ miles wide here. (Photo by former Survey Photographer W. D. Zehr)

— have been recovered. These data are being compared with what is known of today's fish and their condition. In addition, researchers are interviewing commercial fishermen and fish market owners. Their memories and records provide another basis for historical comparisons.

A long-term increase in the rate of sedimentation in the Illinois River has been documented. The depths of Senachwine, Sawmill, Billsbach, Sparland, Whitman, Upper Peoria, and Rice lakes and Babbs Slough have been measured to determine how fast they are being filled with soil. In a recent cooperative study, using depth measurements taken by the Natural History Survey, the Illinois State Water Survey found that, at the present rate of siltation, Lake Chautauqua near Havana will be dry land by the year 2068.

What has happened to duck-food plants and turtles over the last 40 years and the effects of barge traffic on fish are among other subjects being considered at the Havana Laboratory.

The Illinois River hasn't always been as it is today. When the Natural History Survey completes its analysis of the old information, we will know a great deal more about what has happened to fishing, hunting, and clamming as a result of the damming and dredging for a 9-foot barge channel. Current studies will show how aquatic organisms and wildlife are responding to the pollution-control measures being taken in the Illinois valley. In short, we will be in a better position to judge whether future changes in the Illinois River — and other rivers — will be for the better or the worse.

Pesticides in Fox Squirrels

Twenty-eight fox squirrels were shot by hunters during the 1975 season on three adjacent large areas of timber in Fayette County in south-central Illinois. Fayette County is moderately cultivated — corn, soybeans, and wheat are the major crops. Areas of timber and pasture are still common. The fox squirrels collected were analyzed for pesticides in the laboratory of the Section of Wildlife Research by Ron Duzan.

Survey biologists Chuck Nixon and Steve Havera separated this sample of squirrels

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into five groups: lactating adult females, nonlactating adult females, adult males, subadult females, and subadult males. The squirrels were analyzed for DDE, dieldrin, PCB's, and other pesticides.

The concentrations of pesticides found in the specimens were low. Only DDE (a residue of DDT) and dieldrin were detected. Only 3 of the 28 squirrels contained dieldrin. The range of dieldrin concentrations was 0.0005 to 0.0023 ppm (parts per million). However, a surprising number (25) of the 28 specimens contained DDE residues. The DDE concentrations ranged from 0.0008 to 0.0195 ppm, with an average of 0.0037 ppm for the 25 squirrels in which DDE was detected. The highest concentration of DDE was found in lactating adult females, which had an average value of 0.0053 ppm, whereas the nonlactating adult females had the lowest average concentration, 0.0023 ppm. The remaining groups had levels near the average for all squirrels — 0.0037 ppm of DDE.

The probable method of the uptake of DDE and dieldrin by fox squirrels is through their diet. Pesticides wash from agricultural fields into small creeks and streams. Mast-producing trees probably absorb water containing the pesticides. The trees may store the pesticides in their seeds, where they become available to squirrels. Because the lactating adult females had the highest concentration of DDE, it is possible that nursing female squirrels pass pesticides through their milk to their young. Nixon and Havera conclude that DDE and dieldrin are apparently so widespread throughout the environment that they even occur in fox squirrels living in areas less intensively cultivated than east-central and other parts of Illinois.

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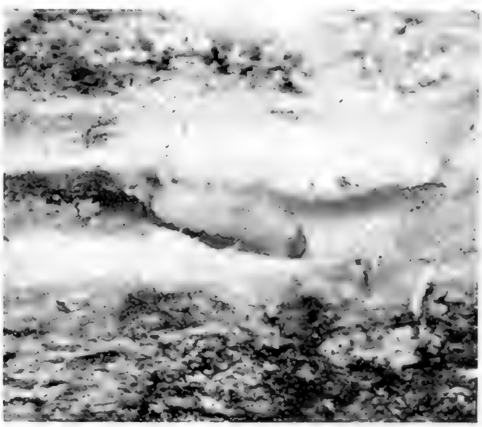
Weevils, Crucifers and Men

Horseradish is a crucifer grown for its fleshy pungent roots. Since the 1890's it has been produced commercially in Illinois in Madison and St. Clair counties near East St. Louis in an area called the "American Bottoms." Half to two-thirds of all horseradish in the U.S. is produced in this area on roughly 1,000 acres by about 30 growers.

Horseradish is propagated from thin side roots or "sets" trimmed from the main root at harvest and stored in coolers or underground pits through the winter. Planting is done in the spring with harvest of the large marketable main roots in October-November; a portion may be left for a spring harvest.

In 1976 a program was begun by the Economic Entomology Section of the Natural History Survey and the Department of Plant Pathology, University of Illinois, to catalog the insects on horseradish and to determine possible vectors of brittleroot, a serious virus-like disease. In May, 1977 Survey researcher Dan Sherrod and extension horticultural adviser Chris Doll found dark-blue weevils feeding on horseradish crowns and larvae damaging the roots (Figs. 1 and 2). Survey entomologist John Bouseman tentatively determined the weevil to be *Baris lepidii* Germar, an insect heretofore known to occur only in Europe and the U.S.S.R. Identifications of adults and larvae were confirmed by D. R. Whitehead and D. M. Anderson, USDA-ARS Systematic Entomology Laboratory, U.S. National Museum, Washington, D.C.

In Europe *B. lepidii* is a pest of such crucifers as turnip, cabbage, cauliflower, and horseradish. Because of its threat to horseradish and other commercial cruci-



Figs. 1 and 2. Adult (left) and larva (right) of *Baris lepidii* in horseradish roots. (Photo by Brian Melin, Survey entomologist)

fers, the Illinois Vegetable Growers Association successfully petitioned the state legislature to pass a special appropriation for research on the weevil. A team of Survey staff — entomologists Dan Sherrod, Cathy Eastman, John Bouseman, Roscoe Randell, and Clarence White with librarian Bonnie Irwin — has been organized to gather historical and biological information on the weevil, determine extent of its threat to horseradish, and develop cultural and chemical means of control.

To date 90 percent of the horseradish acreage has been surveyed. The weevil situation now appears to be more serious than was originally anticipated. Moderate to heavy infestations have been found in 30 percent of the fields. While adult feeding on crowns is negligible, larval damage to roots can be severe. Larvae tunnel underneath the root surface and sometimes down to the heart. While some roots are killed by larval feeding, the primary result is reduction of root quality.

Insecticide screening in laboratory and small-plot field trials has revealed two materials that provide partial control of weevil adults. One, toxaphene, is already registered for use on horseradish. Through the efforts of W. H. Luckmann, head of the Survey's Economic Entomology Section, an emergency exemption has been granted for use of another material — M+M, a commercial preparation of malathion and methoxychlor. High-gallonage applications (100^+ gal/A) have produced the best control. The adults feed in the crown of the root, often below the soil surface making control with insecticides difficult.

Examination of adults indicates that only a very small percentage can fly. This information, together with observations made during the survey, may indicate that weevil infestations are most often a result of the planting of infested sets and the presence of weevil populations in volunteer horseradish in rotation crops rather than a result of inter-field movements of adults.

Much remains to be learned about *B. lepidii* and its impact on Illinois crucifers. Research this winter will include determination of the weevil's life cycle in Illinois, evaluation of other crucifers as potential hosts, and development of a treatment of sets for destruction of eggs and larvae prior to spring planting.

Flies: Who's Who

During the past year Survey entomologist Donald Webb has been involved in systematic studies on the aquatic and semiaquatic flies of the suborder Brachycera. As part of a world-wide revision of the family Athericidae, Webb has revised the two Nearctic genera *Atherix* and *Suragina*. This family of flies was recently erected by B. Stuckenberg of the Natal Museum to include several genera of flies throughout the world.

This study involved borrowing specimens from some fifty museums and universities, in addition to private collections. Over 1,500 adult and immature specimens were examined, involving three species of *Atherix* and three species of *Suragina*.

The genus *Atherix* is common throughout Canada and the United States with numerous females collected as they aggregate in masses to lay eggs. Eggs are laid on stones or vegetation along streams into which the newly hatched larvae crawl. The larvae are aquatic and commonly collected in shallow stream riffles and vegetation. They are predacious and feed on a variety of stream organisms, in particular caddisfly larvae. Before pupation the larvae migrate into the sand or debris along the shore to pupate. Adults emerge and can be collected from May through August.

The genus *Suragina* occurs in southwestern Texas and Mexico, south into the tropics. Adults are collected infrequently, although the females require a blood meal and impart a severe bite. The immature stages are unknown for the Nearctic region.

This study has involved the description of one new species of *Atherix* and the removal of two names to other genera of flies. Descriptions, keys, illustration of morphological characters, and the distribution of each species was presented. The study, appearing in an Entomological Journal this month, is one segment of an overall

Fig. 3. Pileated woodpecker at nest entrance. (Photo by Richard Graber, Survey ornithologist)

study to examine the phylogenetic relationships of several genera of lower bachycerous flies.

Woodpeckers and Old Forest

As various human activities reduce or alter natural habitats in one way or another, it becomes increasingly important from a conservation standpoint to understand more precisely the habitat requirements of all populations. A study of Illinois woodpeckers (now in press) by Drs. Jean W. and Richard R. Graber includes analyses of the vegetation, habitat structure, and terrain used by these species in summer and winter. Knowledge of seasonal variation in habitat requirements is essential to the preservation of populations. In cases where the habitat of a given population differs from summer to winter, survival of that population obviously depends upon some realistic balance in availability of the habitat requirements of each season.

Perhaps the most striking example of seasonal habitat change among Illinois woodpeckers is found in the red-headed woodpecker, which occupies primarily forest-edge, savannah habitats in summer and mature bottomland oak forests in winter. Besides the habitat shift, there is also a geographic shift southward which brings large numbers of red-heads to southern Illinois in winter. This population shows an interesting alternate-year cycle of highs and lows with especially high levels in the odd-numbered years (for example, January 1975 and 1977). These large populations are concentrated in bottomland (especially pin oak) forest, which produces quantities of acorns on which the birds feed. Red-head populations are at least four times as dense in bottomland as in upland forest, and other woodpeckers also favor the bottoms. Pileated woodpeckers are at least three times more numerous in bottomland forest than in upland forest, and flickers and downy woodpeckers at least two times higher in bottomland forests. Only the hairy woodpecker had roughly comparable densities in bottomland and upland, but the hairy still favored old forest in both places.

This habitat preference of the woodpeckers puts them at odds with human foresters, whose long-standing policy has been to cut old forest stands. The old bottomland forest stands are being decimated not only by foresters, but by farmers and reservoir builders. Only two old bottomland forest areas — Beall Woods in Wabash County, and Heron Pond-Little Black Slough in Johnson County — have been preserved in southern Illinois. Serious consideration should be given to the establishment of similar forest preserves on all of the major Illinois streams. Such preserves would be important not only to the nesting and wintering populations but to the large numbers of transients that pass through the area in migration, spring and fall.

Underlying these observations is an important philosophical question on international and national conservation. The question, simply put, is: "Does the legal owner (federal, state, and other) of a resource have a special obligation to the resource?" Consider the long-standing relationship of the red-headed woodpecker with the bottomlands of southern Illinois.

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Much of that population comes from breeding areas outside of Illinois, but the birds are no less dependent upon their Illinois winter range. If we use waterfowl management as a precedent, the answer would seem to be that Illinois — its citizens — should protect the species' Illinois habitats. However, nongame species have not received the same considerations as game species.

Official policy on such questions should be established soon because of the present rapid pace of change. In addition, the pragmatic questions of costs and the important biological questions about size and spacing of preserves need be answered.

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Cristulariella Leaf Spot of Black Walnut

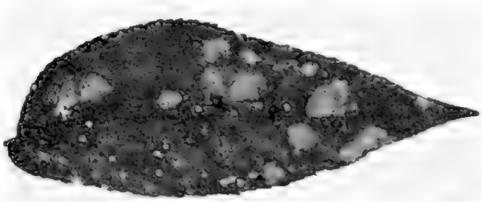
The eastern black walnut is one of the most valuable hardwood trees in North America. Black walnut is valued not only for its wood but for other products. Since the 1960's an expanded export market has increased the demand for walnut logs. In response to the greater market value of black walnut, the number of walnut plantations has increased in many parts of the U.S. Most of these plantings are pure stands of black walnut. From an economic viewpoint such practices are desirable; however, growing trees in monocultures greatly intensifies disease problems, which can easily reach epidemic proportions.

In 1976 Survey plant pathologist Dan Neely and coworkers from the USDA Forest Service reported the association of *Cristulariella pyramidalis,* a leaf-spotting fungus, with the defoliation of black walnut plantations in southern Illinois in 1973 and 1975. This was the first reported occurrence of *C. pyramidalis* on black walnut. Neely and Robert Evers, former Survey botanist, reported the occurrence of Cristulariella leaf spot on 20 species of herbaceous plants not previously reported as susceptible. The plants were native understory vegetation in the black walnut plantations defoliated by *C. pyramidalis.* The fungus is known to have a wide host range.

This disease is apparently sporadic, appearing in mid-summer to fall. Cool, moist periods seem to favor disease development. In Illinois when the disease was reported on walnut, the mean daily temperature from mid-July through mid-August averaged about 75° F in 1973 and 1975, and extensive rainy periods occurred during these times. With these extended periods of rainfall and high humidity, complete defoliation of the walnut trees occurred within 4 weeks.

The symptoms on infected walnut leaflets appear as round necrotic lesions. Infected leaflets may have many lesions, ranging in diameter from 1 to 10 mm. The lesions often coalesce over large surface areas. The small lesions are mostly white, and the larger lesions are brown with raised white concentric rings, giving the appearance of a bull's-eye. Lesions along the veins tend to be wedge shaped. The asexual fruiting structure of the fungus is often seen on the lower leaf surface. The fruiting structures are cone or pyramid shaped, resembling miniature white Christmas trees. Their shape is readily visible with a hand lens.

Since limited information is available concerning this fungus, graduate student Molly Niedbalski initiated an investigation



Leaf spots caused by *Cristulariella pyramidalis* on a black walnut leaflet. (Photo by Survey Photographer Larry Farlow)

of the organism and its disease development on black walnut.

The effects of medium, temperature, and light on the growth of the fungus in culture were tested. Greenhouse-grown black walnut seedlings were used in disease-development studies conducted in laboratory growth chambers. An isolate of the fungus from naturally infected leaves was used to inoculate the seedlings. The effects of light, temperature, relative humidity, and free moisture were tested on lesion development and fungal sporulation. The unusual nature of the asexual fruiting stucture was also studied with the aid of Lee Crane, Survey mycologist. It appears that the entire asexual fruiting structure serves as the inoculum source in nature.

When these studies are concluded, they will contribute to the understanding of the fungus and the conditions favorable to disease development.

Waterfowl Foods and Water Levels

A 28-year study of the relationship of water levels to waterfowl food plants, and of these, in turn, to waterfowl populations is nearing completion. Low-water conditions during the summer months produce extensive mud flats in the backwater lakes of the Illinois River. Many moist-soil plants develop on the mud flats when the growing season is adequate.

Studies by Frank C. Bellrose and his associates at Havana reveal that there is a significant linear correlation between the date when mud flats are exposed, the area exposed, and the growth of moist-soil plants. For maximum plant growth, water levels must decline enough to expose mud flats by June 15. After August 15 there is little germination of these plants and even less opportunity for them to produce seeds before frost.

Because the reduction of the water level of the Illinois River was found to correlate with the production of moist-soil plants, an evaluation was made of water levels and waterfowl abundance. There was little correlation, none significant, between the abundance of various species of ducks in the lakes of the upper Illinois River (above Peoria) and the summer decline of water levels from 1949 to 1976.

This lack of significant correlation is understandable, because mud flats have begun to reappear in this region only in the last few years. The Peoria lock and dam raised the water levels of the upper Illinois River from 1939 onward, immersing mud flats previously exposed during low water. A high sedimentation rate has resulted in the increasing re-emergence of mud flats, so that by the summer of 1976 they were approximately as extensive as they were before 1939.

However, in the river lakes below Peoria mud flats were not submerged by the La Grange lock and dam (operational in 1939) to the same extent as were those above Peoria. Consequently, there is a significant correlation (linear regression) between the degree of low water and the fall abundance of certain ducks. The abundance of the pintail showed the most influence from the prolonged exposure of mud flats in summer, followed by the green-winged teal, blue-winged teal, and wigeon. Other species failed to show a significant linear correlation between fall abundance and summer water levels.

The mallard, the most abundant duck in Illinois, failed to show a linear correlation between fall population and summer low water for two reasons: (1) yearly changes in continental mallard abundance and (2) waste corn in harvested fields that provides an important source of food.

A partial correlation of the three variables (mallard abundance in the lower Illinois Valley, low-water conditions, and fall continental mallard population) disclosed that the size of the continental population was more important than water conditions in determining the abundance of mallards in the Illinois Valley. However, with the variable of continental mallard population changes weighted, summer (low) water levels became a significant factor in affecting the fall abundance of mallards in the Illinois Valley.

The lesser scaup, canvasback, ring-necked duck, and other diving ducks apparently rely so greatly upon animal life for food that their populations are not

Wigeons resting at a private sanctuary a few miles east of the Illinois River near Manito. The wigeon is one of the dabbling ducks whose fall populations in the Illinois River Valley are influenced by summer water levels in the river and the resulting exposure of mud flats and growth of moist-soil plants. (Photo by former Survey Photographer W. D. Zehr)

significantly influenced by summer low water and the concomitant development of moist-soil plants. Thus, summer water conditions play an important role in the abundance of dabbling duck populations in the fall but have little or no effect upon the abundance of diving ducks in the backwater lakes of the lower Illinois River.

Insect Movie in Production

With the aid of a grant from a private foundation and in cooperation with the Morton Arboretum, economic entomologist James Appleby is producing a 25-minute color motion picture on insects and mites that attack trees and shrubs in Illinois.

Work on the movie was begun during the summer of 1976 and is progressing well. The film will depict insects feeding on trees and shrubs, providing action shots of their various developmental stages. Thus far, life stages of the cottony maple scale, euonymus scale, lecanium scale, eastern spruce gall, Zimmerman pine moth, several cynipid galls on oaks, bronze birch borer, and birch and oak leafminers have been filmed. The work will be continued through 1978, with completion of the film scheduled for early 1979. The movie will be made available to public television stations, garden clubs, nurserymen, and others.

Kankakee River Studies

Aquatic biologists from the Illinois Natural History Survey have begun a four-year study of the Kankakee River and Horse Creek near Custer Park, Illinois. The purpose of the study is to obtain biological, physical, and chemical data which will be used to evaluate any effects of the construction and operation of Commonwealth Edison Company's Braidwood Nu-

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clear Power Station and its associated cooling lake on animals, plants, and water quality of the Kankakee River and Horse Creek.

Specifically, the study involves the collection of samples from a stretch of river located from about one mile above to one mile below the mouth of Horse Creek. R. Weldon Larimore is principal investigator, with Michael Sule coordinating field and laboratory operations in addition to studying fish populations along with Don Myrick and Jodie Smith. Other principal biologists include Larry Coutant and Carl Alde (periphyton), Steve Swadener and Gary Warren (benthos), Harry Bergmann and Jeff Hutton (fish eggs and larvae), Allison Brigham (general chemical parameters and bacteria), and Ken Smith (heavy metals and pesticides).

Preliminary data have indicated diverse benthic and fish communities. The benthic study has incorporated a variety of techniques (dredge samples, artificial substrates, invertebrate drift collections, light trap collections, and a rearing program) to examine the dynamics of the river-bottom invertebrate community. Dredge samples taken in April 1977 revealed 65 invertebrate taxa, including 27 genera of Chironomidae. The predominant organisms have been mayflies, caddisflies, riffle beetles, and midge larvae.

The fish study also involves various collection methods, including electrofishing, seining, and hoop net sets, to insure adequate sampling of the fish population. Sampling has already indicated a great variety of species and good populations of sport fishes. Populations of such fishes as walleye, northern pike, smallmouth bass, rock bass, and the northern longear sunfish offer an opportunity to study the life histories and population dynamics of several fish species not common to many parts of the state.

Several aspects of the ecology of the Kankakee River have already become apparent even though the study covers only a restricted part of the river. The Kankakee River is one of the finest flowing-water environments in Illinois and supports diverse populations of vertebrate and invertebrate species. The fine water quality and unusual and diversified habitats present in the river system are responsible for the overall excellent rating which this river has received in the past. The contract between Commonwealth Edison Company and the Survey will make it possible for the Natural History Survey to study the dynamics of this distinctive midwestern river and to gather data which will help determine the effects of the establishment of a nuclear power plant in the watershed.

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Illinois Natural Areas

A recent report "Some Unusual Natural Areas in Illinois," published by the Survey as Biological Notes No. 100, is an expanded revision of a 1963 publication. The earlier work, authored by Survey botanist R. A. Evers, was a report on botanical and scenic features of natural areas in Illinois. For the new publication, Evers was joined by Survey zoologist L. M. Page, and unusual animals as well as plants and scenic characteristics are discussed.

The revision includes descriptions of 33 natural areas. Among the areas discussed in the revision that were not included in the original report are Chain O'Lakes State Park, Iroquois County Conservation Area, Middle Fork of Vermilion River, Embarras River, Illinois Caverns, and Big Creek.

Chain O'Lakes State Park and Conservation Area in Lake County encompasses an area composed of glacial lakes, marshes, disturbed oak woodland, and wet prairie. The area is one of the few in Illinois where black ferns and long billed marsh wrens can be observed. Among the unusual fishes found in the glacial lakes are the pugnose shiner, blackchin shiner, banded killifish, brown bullhead, and Iowa darter. Rare or uncommon plants include the beaked spike rush, tufted bulrush, pitcher plant, twig rush and grass of Parnassus.

Iroquois County Conservation Area is adjacent to the Willow Slough Wildlife Refuge in Newton County, Indiana, enhancing the area as a biological refuge. In and near the area are small to medium-sized streams with sandy bottoms, masses

View of Big Creek in Hardin County, a rocky spring-fed stream. (Photo by Survey zoologist Larry Page)

of submerged vegetation, and headwater marshes. In these streams are fishes peculiar to sand areas, including the ironcolor shiner and weed shiner, and other uncommon fishes such as the lake chubsucker, starhead topminnow, and least darter. Sand-inhabiting reptiles found here but normally more western in distribution are the bullsnake, ornate box turtle, and six-lined racerunner. Among the unusual plants in the forest and prairie are colicroot, white-bract hymenopappus, and nodding ladies'-tresses.

Middle Fork of the Vermilion River in Vermilion County is a high-gradient river with many boulder riffles, clear pools, and extensive raceways over gravel and sand. Many of the raceways are bordered by emergent vegetation. The river has a large variety of aquatic animals that are unusual in Illinois, and the floodplain and bluffs harbor a great diversity of plants and wildlife. The bluebreast darter, a small and brightly colored fish, is found in Illinois only in the Middle Fork, and the rare and unusual salamander, *Ambystoma platineum,* occurs in Illinois only in wooded areas along the Middle Fork.

The Embarras River from Greenup to Newton, in Cumberland and Jasper counties, is unpolluted and mostly unmodified and represents one of the finest aquatic natural areas in Illinois. The river and its environs are sufficiently wild to support populations of the timber rattlesnake and a small fish, the harlequin darter, known to occur nowhere else in Illinois.

Illinois Caverns, in Monroe County, is also known as Mammoth Cave of Illinois, Eckert's Cave, and Burksville Cave. The cave has a number of interesting and unusual animals including one scud, *Gammarus acherondytes,* known only from caves in Monroe and Randolph counties, Illinois. Also found in the cave are cave-adapted (often white and eyeless) millipedes.

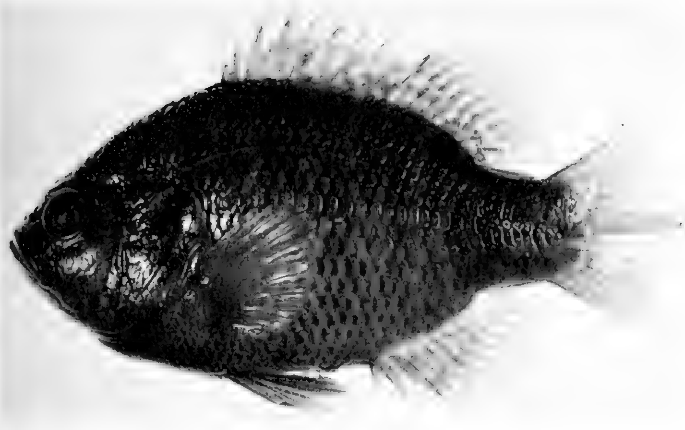
Big Creek is a beautiful, clear, rocky, spring-fed stream in Hardin County that is a near facsimile of some of the Appalachian streams of Kentucky and Tennessee. The stream has populations of three rare crayfishes, relict populations of northern fishes, and several other fishes with very limited distributions in Illinois. These organisms inhabit Big Creek because of its large influx of spring water and preponderance of rocky substrates. A historic attraction on the watershed is Illinois Furnace, the site of an early iron works in Illinois.

Bantam Sunfish in Illinois

Of the seventeen sunfishes occurring in Illinois, eight are members of the genus *Lepomis* which includes several species familiar to local fishermen and naturalists. One species, the bantam sunfish, *Lepomis symmetricus,* is very rare in Illinois and was formerly poorly known even to ichthyologists. The taxonomy, distribution, and life history of this species were the subjects of a study recently published by former Survey ichthyologist B. M. Burr. Copies of this publication, Illinois Natural History Survey Bulletin 31, article 10, may be obtained free by writing to the Chief, Illinois Natural History Survey.

The bantam sunfish was first discovered near Pekin, Illinois, and was later described by Stephen A. Forbes, former chief of the Survey. The species is found in lentic waters characterized by submerged logs, standing timber, and rich vegetation and presently occupies the Coastal Plain province in the mid to lower Mississippi River valley. The life history portion of the study involved two years of field and laboratory observations made on a population in Wolf Lake, Union County, Illinois. The bantam sunfish was found to occupy vegetated margins of the lake, to live a maximum of 3.4 years, to grow to a maximum length of 76 mm, and to feed primarily on gastropods, crustaceans, and immature aquatic insects. At one year of age and a minimum size of 34 mm, the bantam sunfish spawns in nest depressions formed by the male. Up to 1600 eggs may be laid by a single female. Males are aggressive during courtship and sometimes cause the death of their female partners.

Examination of museum specimens revealed that the bantam sunfish shows little morphological variation throughout its range. In some countable characters popu-



The bantam sunfish, *Lepomis symmetricus*. (Photo by Survey photographer Larry Farlow)

lations along the Gulf Coast have lower average values than those in southern Illinois. The bantam sunfish was at one time known from the Illinois and Wabash Rivers but has not been taken in these waters since the 1880's. A reduction in aquatic vegetation, the draining of natural lakes and the stocking of non-native sunfishes are presumed causes for the decimation of the species in Illinois. Because of the limited habitat now available to the bantam sunfish in Illinois, it has been placed in a threatened category in Illinois' latest list of endangered and threatened species.

The study on the bantam sunfish was the eighth life history study on Illinois fishes completed at the Survey. Detailed life history studies provide information to persons conducting environmental studies and contribute to our knowledge of the lesser known non-game fishes.

Fox Squirrel and Winter Food

Fox squirrels eat a wide variety of foods. In the fall, winter, and early spring months, however, tree seed or mast is their primary source of nutrition. In sparsely timbered areas, fox squirrels will often eat corn, soybeans, and osage orange seeds during the critical winter months.

From December through March, 1975 to 1977, wildlife biologist Stephen P. Havera fed nine diets to adult female fox squirrels housed in an environmental chamber programmed for average January conditions of east-central Illinois. The diets tested were acorns of black, red, white and bur oaks; nuts of shagbark and mockernut hickories and black walnut; and corn and soybeans. The amount of food consumed, feces and urine excreted, and changes in body weight were monitored during the experiments.

The average weight change per day of the squirrels on the various diets somewhat paralleled the amount of energy metabolized on each diet. White oak, which had the highest amount of energy metabolized per day, also resulted in the largest increase in weight of the squirrels. Squirrels fed mockernut hickory metabolized the second highest amount of energy per day and showed the second largest average increase in weight. Squirrels fed red oak and corn germ diets had the lowest amount of energy metabolized per day and were the only groups to have average weight losses during the feeding trials.

These results reveal that the significantly higher assimilation coefficients and higher caloric values for shagbark and mockernut hickory nuts require that adult female fox squirrels eat about 59 percent more white, bur, and black oak acorns than hickory nuts to attain a similar level of metabolized energy. All of the acorns had about the same assimilation coefficients; however, red oak acorns differed drastically from the other oaks in the amount of energy metabolized per day. Correspondingly, the red oak diet was the

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only oak diet on which the squirrels showed an average weight loss. Red oak acorns are apparently less palatable to fox squirrels than white, bur, or black oak acorns.

Because fox squirrels ate more white oak acorns, metabolized more energy from them, and gained more weight than on any other acorn diet, white oak acorns are apparently highly palatable to fox squirrels, as they are to other wildlife species. Fox squirrels do not acquire as much energy per day, or extract energy as efficiently, from grain crops of corn and soybeans as they do from mast crops with the exception of red oak acorns.

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More on Herons

Wildlife specialists Jean and Richard Graber are presently analyzing data on Illinois herons, including a survey begun in 1973 of major colonies of the two largest Illinois species — the great blue heron and the great egret. As reported earlier, the available historical data strongly suggested that breeding populations of these two species were declining in Illinois. Other possible interpretations were that the colonies were moving about or that the populations were fluctuating up and down (as natural populations do), and that the data for recent years happened to represent low years.

That possibility still exists, but the knowledge gained from extensive air and ground searches of much of the state's suitable habitat for herons is not reassuring. Few new colonies have been found to make up for colonies lost. Although some colonies show the expected pattern of annual gains and losses, the over-all state population shows a progressive yearly decline of between 12 and 18 percent from 1973 to 1977 for the great blue heron and an average annual loss of 25 percent for

Fig. 1. The Great Blue Heron. (Photo by former Survey biologist George Bennett)

the egret, including a 55 percent loss between 1975 and 1976. The situation appears very serious and calls for special measures of protection.

Recoveries of great blue herons banded in Illinois (especially those banded by Karl Bartel of Blue Island) show the high cost to great blues of unwariness. About two-thirds of the fledged young are lost in the first year, most in the first six months, after which their chances of survival improve. The most common cause of death cited is shooting. In earlier years, the population could apparently sustain such losses and survive, but this is not true now, and hunters should be apprised of the harm being done. Unfortunately, the problem extends all the way to Central America, where some Illinois-raised great blue herons winter. We do not know whether mortality from illegal shooting is increasing, but even at the rate the herons have been killed in the past, it would take a productivity rate of about 2.8 young per adult pair to sustain the population. The *very best* average of young per nest observed by the Grabers was 2.5 young, not counting nests that failed completely.

Better information is needed on production of young and on the entire nesting cycle; however, one cannot study a colony without disturbing it, and disturbance increases food loss to young and perhaps nestling mortality. Yet, without such studies, we cannot hope to learn how to preserve the populations. Careful studies by responsible students should be encouraged, and every effort should be made to reduce human traffic in the vicinity of colonies, roosts, and the heron fisheries. The fisheries are generally located within six miles of the colony, often within a mile, and need to be protected as rigidly as the colony site itself, preferably closed to human traffic from March to September.

The question of whether the heron's problems are related to pollution has received little attention. Because great blue herons nest so high, gaining access to their nests involves great disturbance to the colony. Thus, there are no data on hatching success as a possible clue to pesticide intoxication, and no historical perspective on hatching and fledging rates from which to judge whether these rates are changing. At present the knowledge, if it is obtained, may come too late. Although herons comprise a tiny fraction of the Illinois fauna, for most groups of organisms we do not even know whether the population is changing, let alone why.

The Sam A. Parr Fisheries Research Center

The INHS field station near Kinmundy is one of the many fruitful results of a lifespan of friendship and cooperation between Sam A. Parr and George W. Bennett. Sam was for many years the Assistant Director and chief mover and shaker in the Illinois Department of Conservation, and George was the distinguished Head of the Section of Aquatic Biology in the INHS from November, 1943 until his retirement in January, 1974. Both are now deceased and have become legendary figures in conservation circles in Illinois. The station was established in 1963 as the Marion County Fisheries Research Center. Following Sam's death in November, 1966, George officially dedicated the station as the Sam A. Parr Fisheries Research Center in recognition of Sam's many contributions to the sportsmen of Illinois, and because of his long friendship with the Survey.

The Station sits as an adjunct to the Stephen A. Forbes State Park in order to tap the park's 237-ha reservoir as a water supply for the experimental ponds. Original construction included 9 drainable 1-acre ponds completed in 1963. Five additional smaller ponds were added in 1965. Original station personnel included Homer Buck, Charles F. Thoits, III, and Russell Rose. Thoits left the Survey in 1969 and was replaced by R. J. Baur. The small original staff shared the office of the park ranger in 1964-1965 and later occupied a renovated chicken house until the present quarters were completed in the spring of 1967. The present laboratory comprises about 2,700 square feet, containing an office, fish lab, limnological lab, dark room, large tank room, and a combination library and conference room. Additional fa-

cilities include two storage and service buildings and an outdoor array of 3-meter diameter experimental pools.

The first major project at this new station was to assess the time-honored but untested concept that individual ponds will have inherent productive potentials that will cause them to rank high, low or intermediate on a rather permanent basis. The 4-year study revealed a startling and previously unconceived range of variations, not only from pond to contiguous pond, but by individual ponds in consecutive years. The conclusion was that whether a pond ranked high or low in a particular year was largely due to chance. The major element of chance was believed to be the differences in rates at which, or pathways by which, available nutrients were cycled through the systems. The published results brought the authors an award for the most significant paper published in the Transactions of the American Fisheries Society in the year 1970.

Because of the surge of interest in channel catfish farming, a series of studies were initiated in 1968 to evaluate the potential and problems surrounding the production and/or management of the channel catfish in Illinois, and the interrelationships with such associated species as largemouth bass, bluegills, and golden shiners. Experiments were conducted in pools, ponds, cages and raceways, and the results have been published.

In 1972 a series of studies were initiated to compare the life histories and productivities of the largemouth and smallmouth basses, first as single species, later in association with bluegill, channel catfish and grass carp. Specific evaluations also were made of the influence of both the bluegill and the grass carp on bass production, and of the efficiency of the grass carp as a biological control of aquatic weeds. Additional projects now in progress involve (1) the production of sport fishes in ponds enriched with swine manure, and (2) the use of Chinese carps in the recycling of organic wastes. The studies are yielding useful information in such critical areas as waste management, water quality control, and the production of protein.

New Aquatic Fungi

It is difficult to characterize an aquatic fungus or even define the aquatic environment itself. Nearly any fungus that can be grown in submerged shake culture is potentially aquatic. Furthermore, there are micro-aquatic habitats such as the aqueous phase between soil particles, slime fluxes of trees, nectaries of flowers, and films of sugar solution on the surface of ripe fruit each of which has a fungal flora. The work of Survey botanist, J. Leland Crane, is presently limited to large volumes of fresh water such as swamps, streams, rivers, ponds, and lakes, and an aquatic fungus is regarded as any fungus that is normally completely submerged in these habitats for some period of its life cycle.

Aquatic Ascomycetes are abundant in freshwaters, their richest source being submerged, dead stalks of reed swamp plants and submerged wood in the form of waterlogged sticks of various kinds of trees. This submerged aquatic Ascomycete flora is large and poorly known, and many species remain to be described. There is also a large flora of the asexual stages of fungi such as aquatic Hyphomycetes found growing on submerged decaying leaves and twigs of broad-leaved trees and shrubs in well-aerated water or aquatic Sphaeropsidales which are also not uncommon on submerged, dead, reed swamp plants. The taxonomy of both these groups is in need of careful study.

Fig. 2. Scanning electron micrograph of *Trichocladium* on submerged balsa wood (X1,020). (Photo by J. Leland Crane)

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Recently, in research leading to the identification of the fungi encountered in these aquatic habitats, Lee Crane found a new species belonging to the genus *Trichocladium* Harz. This species was collected from a cypress swamp in southern Illinois containing large quantities of decaying vegetation consisting mostly of submerged and floating aquatic plants and litter from cypress and tupelo trees. The swamp becomes extremely anaerobic in the summer and in the winter when it is covered with ice. However, oxygen concentrations are high in the spring due to photosynthesis of aquatic flowering plants and algae before light is limited by leafing-out of the canopy of trees. The new species of *Trichocladium* is characterized by solitary or aggregated conidia with 3-4 septa that are of two distinct morphological types. This *Trichocladium* species is marked by the reticulate ridges on the surface of the spores as in the figure.

The fungi of aquatic habitats is so poorly known because mycologists have traditionally devoted most of their time to the study of terrestrial fungi. In recent years, aquatic fungi have received increased attention largely due to man's concern with environmental aspects of aquatic ecology. Pollution of our streams, rivers, and lakes is common; therefore, knowledge of the kinds, frequency, distribution, and role of aquatic fungi in these situations is important.

Custom Spray Operator's School

The Thirtieth Custom Spray Operator's Training School was held January 3-5, 1978, at the University of Illinois. The Ground Sprayer's Association and Aerial Applicator's Association held a program January 3 at the Ramada Inn, Champaign, directed at those persons in custom pesticide application. The formal program was held at the Illini Union on January 4 and 5. Speakers from the University of Illinois, and several invited speakers from outside the University, presented talks on the many facets of agricultural pesticides.

The Custom Spray School began in 1949, the brainchild of H. B. Petty, then Extension Entomologist. Even at that early date it addressed problems in application, safety, laws and regulations, and effective pest control. Attendance has grown steadily over the years to a record of 1,705 in 1977. Now under the leadership of Steve Moore, Extension Entomologist at the University of Illinois and the Illinois Natural History Survey, the Custom Spray School has become renowned throughout the Midwest drawing people from as far away as California, Kansas, and Ohio.

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Sulfur and Ecosystem Productivity

In recent years, society has been concerned with adverse effects of acid compounds of sulfur circulating in our atmosphere, primarily as the result of burning fossil fuels and smelting of ores. These concerns relate to human health, deterioration of man-made structures, and the general health of our ecosystems. Adverse effects are particularly apparent where ecosystems have developed on rock and geologic materials that are inherently acid or of low buffering capacity.

In an appendix in their newest book, *The Biogeochemistry of Blue, Snow and Ross' Geese,* Harold C. Hanson and Robert L. Jones have presented examples of the association of high biomass production (particularly animals) with high concentrations of sulfate in saline environments. For example, the western prairies are rich in sulfates of calcium, magnesium and sodium. Because rainfall doesn't exceed evapotranspiration, these nutrients are retained in the upper soil horizons rather than being leached downwards or lost to surface runoff. The capacity of the high plains to sustain huge numbers of ungulates, particularly buffalo (bison), can be related not only to protein rich grasses, but also to a luxury consumption of minerals thereby permitting bacteria and protozoa of the rumens of the animals to synthesize additional proteins and particularly to use sulfates present in the environment.

Virginia or white-tailed deer. (Photo from the Wisconsin Department of Conservation)

One has only to read Audubon's journal from his travels of the upper Missouri River to appreciate the wealth of wildlife produced on the prairies. But what of the wood buffalo of the coniferous forest zone of northern Alberta? A review of the environment of these northern buffalo reveals that large portions of their range south of Great Slave Lake is underlain by gypsiferous rocks (strata of calcium sulfate). An area north of the western portion of Great Slave Lake is characterized by alkali (sulfate) encrusted botoms of dried out ponds. A desolate and seemingly unproductive appearing area, but buffalo, reintroduced to their former range, thrive there. Analogous to this mineral encrusted environment is the former range of the buffalo in a part of Wyoming where the vegetation was mineral encrusted, but the area nevertheless produced the best buffalo in respect to carcass condition, according to a frontier trapper J. Osborne Russel.

The range of the buffalo extended into the eastern and southeastern states, but early accounts indicate the relatively small scattered herds of his region were greatly dependent on mineral licks for their nutritional welfare and possibly survival. One early writer refers to "the sulphur or salt springs" at one of the famous lick sites in Kentucky. The thesis that sulfur-rich environments nutritionally benefit ruminants is also supported by a study which showed that sulfate-supplemented feeds given cattle and sheep increased the amino acids in the rumen by nine to twenty times.

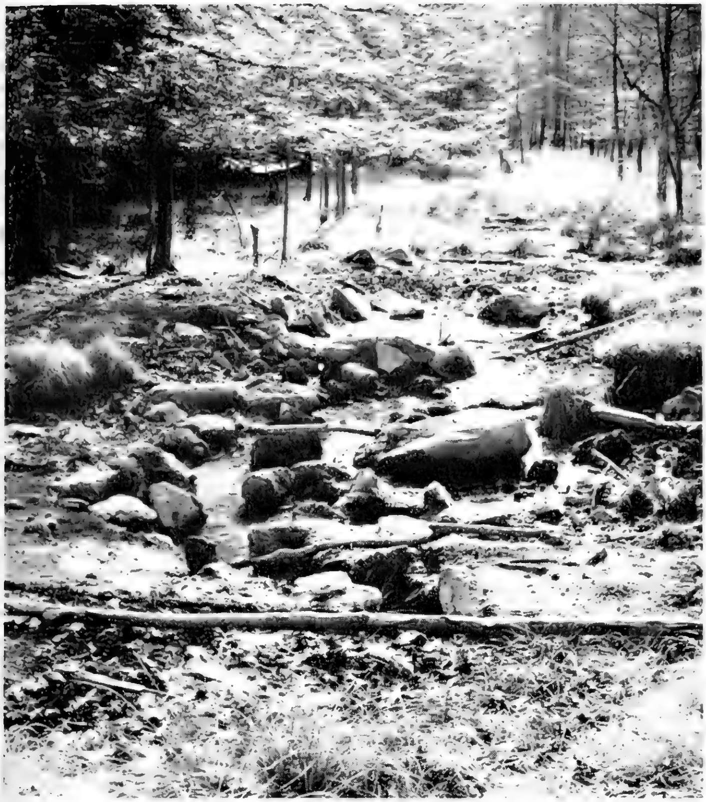
Do these observed associations of wild ruminants with high-sulfur environments have any implications for the present-day livestock industry? In recent weeks, the news media have featured the experience of three Georgia farmers who obtained greatly improved growth from steers fed kiln dust produced by cement manufacturing plants. These findings have been confirmed by feeding experiments by U.S.D.A. scientists at Beltsville, Maryland. The scientists were unable to provide a rationale for the gains they found in feeding samples of the cement dust. Hanson and Jones hypothesized on the basis of their studies of sulfur in the environment that part of the gains relate directly to the sulfur content of the dust. Cement, apparently by design, contains 4-5 percent gypsum. The kiln dust fed the experimental steers contained 2.33 percent sulfur. Thus, the microflora of the rumen had an abundance of readily available sulfur for the synthesis of sulfur-containing amino acids. Proteins cannot be synthesized unless all the amino acid building blocks are simultaneously available. The microflora of the rumen synthesize the amino acids that the cow and all other mammals cannot synthesize by virtue of their physiology. The protein increment absorbed above dietary intake is obtained from the bacteria and protozoa in the rumen. This manufactured protein passes into the digestive tract for digestion and absorption.

Jones and Hanson are currently studying the composition of mineral licks of wild ungulates across the continent. Among the elements of physiological importance, sulfur and/or calcium are consistently abundant in these samples. In light of these findings and the news releases regarding the virtues of feeding cattle kiln dust produced in manufacturing cement, the following notation which accompanied a "lick" sample furnished by R. E. Keiss, a game biologist with the Colorado Division of Wildlife, is particularly meaningful: "This material is from an area where ready-mixed concrete trucks are washed. Bighorn sheep have started using this area and are specifically seeking out this material."

When wet, soils of the alkaline country of the West became anaerobic due to bacteria which reduce sulfates to sulfides. The soils then appear to be conducive to the proliferation of the bacterium *Clostridium botulinum* Type C which produces toxins deadly to waterfowl and other birds. If an association of *Clostridium* with high sulfate soils seems suspect, how do we explain the fact that the only site in Wisconsin where botulism outbreaks occur with any regularity is at the mouth of the Fox River at the south end of Green Bay? It is significant that 17 paper companies south of Green Bay have dumped sulfite liquors into the Fox River for many years and that Type E phase of the botulism organism has been found in fishes in Green Bay. Is the source of these infections — to which fish are apparently immune — also related to sulfur-rich sediments that presumably characterize the bottom of the south end of Green Bay? Can the massive die-offs of loons from botulism that have occurred in the fall on Lake Michigan have their origins in the sulfate pollution of Green Bay waters?

The hypothesis that sulfur compounds are primary constituents of both "salt licks" and wet soils associated with botulism outbreaks came full circle with the finding of a report on a lick heavily used by deer in southern Ohio. Sulfate was one of the major constituent ions found in this lick, and it had to be fenced off, for the deer using it were dying of botulism!

Nevertheless, in an aerobic situation, sulfate-rich waters of the prairie are highly productive of invertebrates which in turn form the base of the notable duck produc-



A mineral lick in Pennsylvania. Soil around rocks has been mined and eaten by deer. (Photo by J. S. Jordan, U.S. Forest Service, Warren, Pennsylvania)

tion on the pot-hole sections of the western plains. It is significant that the largest fairy shrimp known, *Branchinecta gigas,* is found in the "salt and soda sloughs" of southeastern Alberta. A recent irruption of "supershrimp" (*Axius serratus*) occurred in the Straits of Canso, Nova Scotia. Once thought to be extremely rare, these burrowing shrimp established dense populations in a highly polluted section of the straits. What were the polluting industries? A gypsum dry wall plant and a pulp and paper mill discharge wastes to these waters. Sulfates and sulfites as well as organic wastes would be major components of such waste discharges. Perhaps a capstone to the hypothesis of Hanson and Jones that an abundance of available sulfur has a profound effect on biomass production is the dramatic recent discovery of a rich oasis of invertebrate life found off the Galapagos Islands and attributed to a food chain that has hydrogen sulfide as its base (*National Geographic Magazine,* October 1977).

Numerous other examples have been located by Hanson and Jones, but in essence the investigators believe that the role of sulfur in ecological productivity is neither adequately understood nor appreciated.

Alfalfa Weevil Parasite Production

Many species of parasitic hymenoptera have been imported and released in the U.S. and Canada to help regulate populations of the alfalfa weevil, *Hypera postica* (Gyllenhal). One of the most important and successful species to be introduced is *Bathyplectes curculionis* (Thomson), an endoparasite of alfalfa weevil larvae. Through initial releases in 1911, subsequent releases, and natural dispersal, *curculionis* is now established throughout the range of its host.

Dynamic models of the alfalfa weevil's life system are being developed by Survey entomologist W. G. Ruesink for use in pest management programs. Since *curculionis* is

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such an important natural enemy, it is essential that these models include its effect on the weevil. Among the more important processes in the parasitism submodel are: 1) egg production and deposition by the parasite, and 2) distribution of those eggs among available hosts. Writing equations to describe these processes is relatively simple once the biological relations are described quantitatively. Although there is an abundance of literature pertaining to *curculionis,* only a few researchers have dealt with quantitative aspects of the host/parasite interactions, or with the effect of these interactions on the population dynamics of the alfalfa weevil.

Survey entomologists R. J. Barney and D. P. Bartell used several laboratory experiments to determine the effect of host density, temperature, and parasite age on the reproductive potential of *curculionis.* They found that nearly 100% of the host larvae were parasitized at very low host densities, while at very high host densities each parasite would attack about 30 hosts per day. In the laboratory, this parasite did not differentiate between unparasitized hosts and those already parasitized; instead it laid its eggs at random among all available hosts, even though only a single parasite can succesfully mature in one host.

Temperatures ranging from 10° to 30° did not affect the number of hosts parasitized. This means that *curculionis* can find and attack alfalfa weevil larvae successfully over the range of temperatures normally encountered in Illinois alfalfa fields.

The age of the adult parasite strongly controls its ability to parasitize hosts. During the first day of its life, each adult laid an average of 5 eggs, while on days 2, 3, and 4, averaged about 15 eggs per day. After the 4th day, very few eggs were laid, and the average age at death was 4.8 days.

Equations have been written to fit these findings, and the equations have been incorporated into the alfalfa weevil model. This is an example of the interaction between biological research and population modeling that frequently occurs: in developing a model for whatever purpose, gaps in our understanding are revealed and research must be performed to provide the needed information.

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Research on Urban Tree and Shrub Problems

For several years, Illinois municipalities have invested considerable sums of money for trees to replace American elms killed by Dutch elm disease. These investments have generally improved the physical environment of municipalities and have increased the aesthetic value of both private and public property. However, due to various ecological, horticultural, and pathological problems, many of the replacement trees have not survived or produced satisfactory growth. Consequently, plant pathologist Gene Himelick has initiated an extensive research effort to determine specific causes for poor survival and growth rates and to develop practical transplanting and other cultural practices that will contribute to increased plant survival and improved vigor.

The research effort will give a basis for amending and expanding the specifications for species selection, planting, and mainte-

Elms arching above an urban street. This photograph was taken in a city which has an effective Dutch elm disease control program, but in many cities the elms have died and are being replaced with other tree species. (Photo by Gene Himelick)

nance, and it will result in such tangible benefits as a shorter establishment period and fewer replacements following planting. Not only will this research offer the potential for reduced establishment and maintenance costs in the future, for both the private homeowner and the municipality, but it will also contribute substantially to the improvement of the physical-aesthetic quality of urban areas.

Several municipalities have been approached to assist in financing this research, and grant support has been received recently from four major cities.

The research is divided into three major phases. To complete each phase will require a minimum of 3 years of field work. Phase I involves the surveying of several thousands of recently transplanted trees to measure and record data on existing woody plants along municipal parkways and streets in various municipalities in Illinois. Phase II will involve identification and measurement of causes of decline in established trees in several randomly selected municipalities. In phase II the researchers will also attempt to determine which tree species, varieties, and clones do well under urban growing conditions. Tree clones showing disease and insect resistance and outstanding form and growth characteristics in the field surveys will be propagated for future evaluation and recommendation for commercial nursery production. Phase III will include intensive studies to measure the effects of various horticultural and transplanting practices as they relate to mechanical root injury, root regeneration, and diseases of tree roots which develop after transplanting.

Read Any Good Books Lately?

The library of the Illinois Natural History Survey was founded at the first meeting of the Natural History Society of Illinois in 1858 and has always had an official librarian, a professional since 1906. The original collection consisted mainly of reprints received by the members of the society and publications received through an exchange program.

In 1861 the society received its charter from the state legislature and was located at Normal. It became the Illinois State Laboratory of Natural History in 1877. It was transferred to Urbana in 1885 so that the laboratory director, Stephen A. Forbes, could also serve as professor of zoology and entomology at the Illinois Industrial University.

Dr. Forbes brought the library with him, and in 1928 it became a part of the University of Illinois Library, with the collection kept separate but made available to university students and faculty. The Natural Resources Building, which houses both the Illinois Natural History Survey and the Illinois State Geological Survey, was built in 1940. At that time the Natural History Survey Library became a full departmental library of the University of Illinois Library. An agreement was reached between T. H. Frison, Chief of the Survey, and C. M. White, Director of the University Libraries, providing that the Survey would provide the building, furniture, and staff for the library and the University Library would provide a budget for the purchase of books and serials and do the technical processing.

The library is arranged according to the Dewey Decimal System and contains about 32,000 volumes. The collection is about 80 percent serials and 20 percent monographs. A few items are on either microfilm or microfiche, and the library has a reader for each.

The exchange program, which began in the 1800's, has been maintained and expanded to the extent that about two-thirds of the library's serials come from exchange partners. The Survey sends its publications to over 550 institutions throughout the world, and in return receives their publications for the library collection.

The subjects covered in the collection reflect the research projects done by the Survey staff through the years. Entomology is the area covered most thoroughly, but there are extensive works also in botany, ichthyology, ornithology, wildlife, aquatic biology, and economic entomology.

The library is open to the public as well as University of Illinois students and faculty and Natural History Survey staff members, and the librarian is available to

Illinois Natural History Survey Technical Librarian Doris Sublette reviews periodicals for articles that may be of interest to Survey staff members. (Photo by Survey photographer Larry Farlow)

help in locating books and articles and in making a search for literature relevant to subjects in the area of natural history. Only members of the Survey staff may check materials out of the library, but the library has a copying machine for the use of its patrons.

As a part of the University of Illinois Library, the Natural History Survey Library participates in the extensive interlibrary loan system, making its materials available to libraries worldwide. The INHS Library is an affiliate library of the Lincoln Trail Library System and is a member of an informal group called IPAHGEIS (Inter-Professional Ad Hoc Group for Environmental Information Sharing).

Release Cutting for Hickories

Hickory seed is a primary food of Illinois squirrels, particularly during the fall and early winter, when both gray and fox squirrels are rapidly gaining weight and storing body fat.

Because hickories have slow growth, generally poor form, and low market value, foresters usually have ignored them in their silvicultural studies of midwestern hardwoods. Hickories are relatively tolerant of shade and seem to increase best under light cutting, where the canopy remains intact and the faster growing trees that are intolerant of shade are unable to take over in the understory. The recent switch from selection cutting to clear-cutting threatens to reduce the amount of hickory in future stands.

Survey wildlife biologists Charles Nixon and Lonnie Hansen are investigating a number of methods for insuring that at least a few hickories reach seed bearing size in these hardwood clear-cuts.

One approach involves release cutting around selected hickory stems in 7- and 15-year-old clear-cuts, where all competing stems are removed from around a suppressed hickory. The investigators selected 24 pairs of hickory sprouts in a 7-year clear-cut and 40 pairs in a 15-year clear-cut. Stems were paired by species, total height, and stem diameter at 1 meter, and one stem of each pair, selected by coin flip, was released by cutting out all competing stems.

Three growing seasons after release,

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stems of pignut, mockernut, and shagbark hickories averaged larger stem diameters and shorter heights than the control stems. Released stems of 15-year-old mockernut hickories were significantly larger in diameter and significantly shorter in height than comparable control stems. Stem diameter and height growth of released stems did not differ significantly from their paired controls for either shagbark or pignut hickories at 7 and 15 years.

The reduction in height growth shown by released hickories is apparently a normal response to sudden release from competition. Such a response has been reported for released stems of red oak, tulip tree, black cherry, and yellow birch.

However, basing their conclusion on the results of release cutting for these species, the Survey biologists expect their released hickory stems to grow at a faster rate than the controls during the next few growing seasons. They plan to remeasure all stems after five growing seasons, at which time they hope to be able to determine if a single release cutting is a feasible means of insuring that some hickories will reach seed bearing size in clear-cuts.

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Winter Feeding of Squirrels

Winter is considered a critical period for fox squirrels (*Sciurus niger*), and it is a breeding season for both fox and gray squirrels (*S. carolinensis*). The winter survival of potential breeding squirrels and their reproduction depend mainly on the size of the fall tree seed crop (mast) and on the severity of the winter. In winters of low mast and severe weather, squirrel populations may suffer.

Fox squirrels readily eat corn during the winter months. Gray squirrels may not eat corn as readily as fox squirrels, but it may be part of their diet. Some biologists believe that under certain conditions, winter feeding may be of value to squirrels. Shelled corn has been used in winter feeding of fox squirrels and gray squirrels, but the results of these supplemental feeding studies have been inconclusive.

Wildlife specialists Stephen P. Havera and Charles M. Nixon designed a study to determine the effects of supplemental corn supplied in winter to populations of gray and fox squirrels in mature and in pole-sized (average dbh 25.4 cm) mixed hardwood forests. Populations of fox and gray squirrels were provided with shelled corn (*Zea mays*) for three winters in a mature mixed hardwood forest and for two winters in an even-aged 40-to-50-year-old oak-hickory forest in central Illinois. Havera and Nixon found that corn provided no obvious benefits to squirrels in the mature mixed hardwood forest with respect to reproduction, population density, survival, physical parameters, or reduction in disease. In the even-aged timber, the

Fox squirrel. (Photo by former Survey photographer, W. E. Clark)

numbers and survival of squirrels were higher where corn was provided, but unauthorized squirrel hunting on one of the study areas may have influenced this result.

To evaluate the use of unharvested grain as a method of supplemental feeding for squirrels, standing corn and soybeans (*Glycine max*) were left unharvested during the fall of 1975 approximately 10 m from timber. Six rows of standing corn were left unharvested in two fields in McLean County. Four rows of soybeans were left unharvested adjacent to a mature oak-hickory stand in Shelby County. Squirrels made little use of unharvested corn and soybeans left in fields adjacent to woodlands, but use of corn increased somewhat in March.

Havera and Nixon concluded that corn apparently is not a nutritionally adequate supplemental food for squirrels. They also do not believe that winter feeding with corn or soybeans is justified during most winters in the Midwest. The natural composition and diversity of the hardwood forests in the Midwest insures, except in extreme mast failures, that squirrels will find adequate nutrition. Havera and Nixon found that fox squirrels collected throughout Illinois in early spring were in just as good physical condition as those collected in the fall, and that fall-to-spring survival of squirrels on their study areas was higher than spring-to-fall survival. Perhaps winter is not as critical a period for squirrels as it is often considered to be.

Lake Shelbyville Mercury

In 1974, wildlife specialist William L. Anderson and analytical chemist Kenneth E. Smith found that muscle tissues of largemouth bass in Lake Shelbyville contained concentrations of mercury which exceeded the 0.5-part-per-million (ppm) limit set by the U.S. Food and Drug Administration. Subsequent collections and comparative analysis by several laboratories confirmed these levels in both largemouth bass and walleyes. These fishes are near the top of the aquatic food chain, and the appearances of high mercury concentrations in their tissues is indicative of mercury contamination at lower trophic levels and quite probably in the lake itself. Because Lake Shelbyville and its watershed are in a prime agricultural setting with little industrialization, these excessive mercury concentrations are particularly distressing.

Attempts to support further research met with success in October 1977, when the Illinois Institute for Environmental Quality and the Illinois Natural History Survey funded the current project to investigate the occurrence, distribution, and accumulation of mercury in Lake Shelbyville and its biota. Planned as a 2-year study under Smith's direction, this study will sample the water, soil, sediment, aquatic and terrestrial plants, benthic organisms, plankton, and fishes of the lake for mercury analysis. Results of these analyses will hopefully answer the question of the origin of the mercury in the lake, its overall distribution, and how completely it has infiltrated the food web of the lake. It is also hoped that the results may allow the avoidance of similar problems in other lakes in mid-America.

To date, samples of lake sediment and monthly water samples from Lake Shelbyville have been analyzed for mercury by cold-vapor atomic absorption spectrophotometry. Of the water samples, only the October samples showed values above 0.1-part-per-billion (ppb), the detection limit of the procedure, and ranged from 0.1 to 9.4 ppb. The samples collected during November and December were uniformly at 0.1 ppb detection limit. It's possible that the November samples were abnormally high, or that water from the lake contains much lower mercury concentrations than do autumn waters. Spring and summer samples should resolve this question during the coming year.

The analysis of the sediment samples gave wide ranging values from <1 to 230 ppb without any apparent pattern among the samples. Interpretation is complicated by the varying particle sizes in the sediment samples. Experiments are in progress to relate the particle size to the amount of mercury that can be absorbed by the sediments. These data should allow for better

Pherormone trap for black cutworm baited with virgin female. (Photo by entomologist Brian Melin)

interpretation of the mercury in sediment data from Lake Shelbyville.

Black Cutworm Trapping

The life history of the black cutworm, *Agrotis ipsilon,* is not fully known for the north-central United States where the destructive larval stage attacks seedling corn during May and early June. The origin of these larvae has been the subject of debate. Did they overwinter as larvae, or did they arise from eggs laid early in the spring?

A study by entomologists Lynn Pautler, William G. Ruesink, Hans Hummel and William H. Luckmann was undertaken to develop and test a method for early season detection of adults in Champaign County, Illinois. A sticky trap baited with virgin female black cutworm moths reared in the laboratory along with a blacklight trap was evaluated to determine which method was the better indicator of adult black cutworm presence and density. The virgin female black cutworm produces a pherormone which attracts male moths and the blacklight trap attracts both sexes of moths. The traps were all located in an abandoned orchard converted into a tree nursery in Urbana, Illinois.

The earliest black cutworm moths trapped were two males, one taken on March 14 and the other on March 15, 1977, in the sticky trap baited with virgin female moths. Additional male moths were caught in the sticky traps on March 27 (two) and on March 28 (14). During this period (March 15 through March 31) the blacklight traps caught three males and one female moth.

Seedling corn damaged by third and fourth instar black cutworm larvae was found in a field near the study area on May 11, 1977. The centigrade-degree-day accumulation from April 1 to May 11 was 210, an amount sufficient for development from oviposition to third and fourth instar larvae. It seems likely, then, that the larvae damaging corn in Champaign County in May developed from eggs laid by moths flying in early spring, rather than having overwintered as early instar larvae.

For the entire season 2.6 times more males were captured by the traps baited

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with virgin female moths than by the blacklight traps. More importantly, the baited traps attracted 6 times more males during March through May than did the blacklight traps, and the blacklight traps failed to detect the early moths (mid-March) caught in the baited traps.

More Flies – the Genus Dialysis

As part of an ongoing systematic study of lower brachycerous flies, Survey entomologist Donald Webb has recently revised the genus *Dialysis*. This study involved borrowing specimens from some fifty museums and universities, in addition to private collections. Over 1,000 specimens were examined, involving nine species.

The genus *Dialysis* is widely distributed in the United States, occurring from California to the Canadian border east to southern New Brunswick and northern Georgia. Three of the nine species occur in Illinois. Adults can be collected on herbaceous vegetation in wooded lowlands from April to August. The immature stages of this genus are unknown in North America, and little of their adult biology has been determined.

The study has involved descriptions of two new species and the synonymy of two species names with previously known species. Descriptions, keys, illustrations of morphological characters, and the distribution of each species were presented. This study is another segment of an overall study to examine the phylogenetic relationships of several genera of lower brachycerous flies and is preliminary to a faunal study of the flies of Illinois.

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Green Slime and the Gizzard Shad

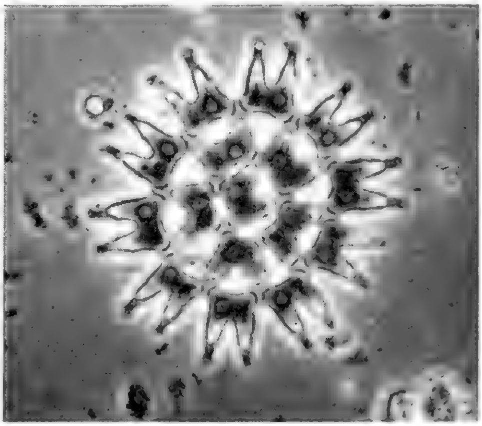
Several unflattering names, such as pond scum, green slime, and even frog spittle, have been used for plants properly known as algae. Most people are aware of algae as the green scum that floats on ponds and lakes in mid to late summer, but few realize that certain kinds of algae are also suspended in the water column and are attached to the sediments under the water and along the shore. Examples of phytoplankton (algae suspended in the water) and periphyton (algae attached to the lake bottom or to objects in the water) illustrating their beauty and uniqueness of shape are *Pediastrum duplex* var. *reticulatum* and *Gomphonema acuminatum* also known appropriately as the "naked lady."

Algae constitute a major part of the organisms that convert sunlight into organic matter in most waters, and algae are responsible for the production of a large percentage of the atmospheric oxygen. These plants also provide food for zooplankton (weakly swimming microscopic animals), which in turn are consumed by certain fishes. Some fish are even directly dependent on algae for food; one of these is the gizzard shad.

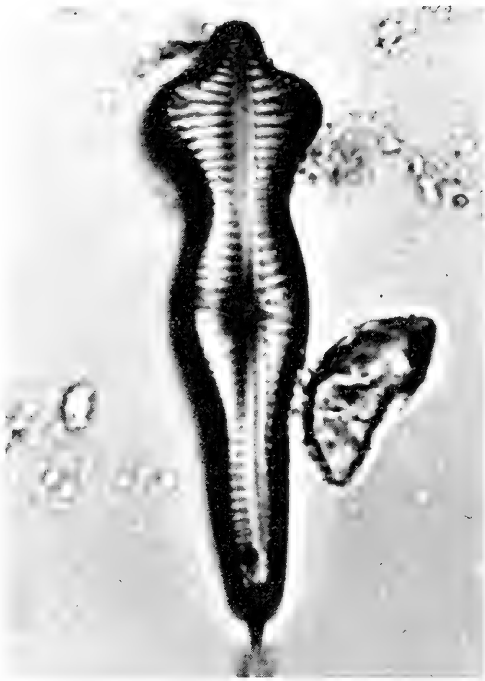
Although the gizzard shad is not a fish sought by fishermen, it is probably the most important forage fish found in midwestern lakes and reservoirs. The gizzard shad is therefore a direct link between algae and the game fishes. The successful spawning and growth of the gizzard shad are important for the success of many game fish, especially the largemouth bass, which is strongly dependent on the shad for food. It is therefore important to understand the reproduction, growth, and feeding habits of the gizzard shad. Understanding the importance of periphyton and phytoplankton abundance to the success of the gizzard shad could lead to better fish management in the future.

In relation to gizzard shad feeding habits, phycologist Larry Coutant has studied the dependency of gizzard shad on algae for food in two Illinois lakes during 1975 and 1976. The two lakes studied were Lake Sangchris, a power plant cooling lake, and Lake Shelbyville, a river reservoir. Analyses were carried out in part to determine gizzard shad food sources and possible power plant influences on shad diet and feeding behavior.

Gizzard contents of shad from 40 to 340 mm in length from different areas of the



Pediastrum duplex var. reticulatum, an alga common in phytoplankton.



Gomphonema acuminatum, the "naked lady," an alga common in periphyton.

two lakes contained primarily algae, particularly pennate diatoms, a special group of algae common to most waters. Blue-green algae, pigmented protozoans, and zooplankton were also present in gizzard contents but were less common than diatoms.

Certain groups of algae are found primarily in the phytoplankton, and other groups of algae (including certain pennate diatoms) are found primarily in the periphyton. Therefore, it is possible to determine from the algae found in their gizzards where gizzard shad of different lengths were feeding.

Smaller gizzard shad ate more phytoplankton than did the larger gizzard shad, which apparently ingested more periphyton. This trend was less apparent in shad from Lake Sangchris, but some evidence of this relationship was found there as well as in Lake Shelbyville.

Another interesting result was that the highest concentrations of organisms were found in shad taken from the power plant intake arm of Lake Sangchris, while the lowest organism concentrations were found in shad from the discharge arm of Lake Sangchris. Shad from two locations in Lake Shelbyville produced results intermediate between the values obtained from Lake Sangchris. These results may be due to the availability of algae in the locations where shad were feeding. Certain minimum algal populations may even prove to be of major importance for adequate maintenance of gizzard shad populations.

Studies of gizzard shad feeding habits have greatly increased our understanding of the importance of fish-food organisms in fisheries. The monitoring of many fish-food organisms, including periphyton and phytoplankton, may prove to be more and more valuable to the proper management of bass and other game fish in the future.

Computer Storage of Soybean-Pest Literature

Since 1969 the Illinois Natural History Survey and the University of Illinois have been studying arthropods associated with soybeans. Because of the economic importance of this crop, this program has created two service-oriented units that support its research projects.

One of these units is the Soybean Insect Research Information Center (SIRIC), which operates a computerized information storage and retrieval system on the literature of insects and mites associated with soybeans.

Initially, Jenny Kogan and her associates at SIRIC used a manual system, but with the rapid increase, beginning in the late 1960's, in the number of papers published on soybean pests, a computerized system was required.

The objectives of SIRIC are:

1. To compile literature on soybean-related insects and mites and to establish a data bank for this literature
2. To organize a collection of relevant documents (journal articles, book chapters, reports, etc.), using code word descriptors for input and computerized retrieval
3. To compile and publish bibliographies of key soybean pests
4. To help soybean researchers, extension workers, and others with their information needs

The SIRIC literature collection now approaches 17,000 documents with about 16,600 documents fully processed and stored on magnetic tapes. Copies of the documents are filed by accession number. Bibliographic references to these documents are stored in a computerized file for retrieval on the Cyber 175 computer of the University of Illinois.

To select items to be included in the data base, SIRIC researchers check standard abstracting and indexing journals or their computerized data bases. They carefully check all documents that are added to the system for additional references. In addition, they correspond with researchers in the USA and abroad to obtain relevant documents. These articles are often published in foreign journals not easily located in U.S. libraries, making SIRIC a valuable depository of foreign soybean entomology literature.

The criteria adopted for selection of relevant documents are: (a) papers that deal with soybeans and with soybean-associated insects or mites, including their natural enemies; and (b) papers that deal with a list of selected soybean pests and their important natural enemies. The literature of these species is surveyed independently of their plant associations. For this reason SIRIC contains many documents on crops other than soybeans, such as corn, cotton, and alfalfa.

Requests for service are received from researchers, extension workers, students, and other interested persons working with soybean insects here and abroad. Computer searches reflect the information needs of users and the subject contents of documents in the data base. A key component of the system is its controlled vocabulary. A Hierarchical Code Descriptors (HCD) thesaurus, specially compiled for SIRIC, is used in input and output operations.

Bibliographies compiled and published within the framework of SIRIC have been widely distributed to interested researchers. Four bibliographies have been published in the series on the literature of arthropods associated with soybeans, and a fifth bibliography is in its final stages of preparation. It is a compilation of the literature of two species, *Heliothis zea* and *H. virescens*, considered the number-one agricultural pest complex in the USA. This bibliography will contain about 5,800 references and a complete subject index as a preliminary key to this huge literature.

SIRIC is housed in the Illinois Natural History Survey and is sponsored in part by INTSOY, the University of Illinois International Soybean Program; the Office of International Agriculture of the University of Illinois; and the Illinois Agricultural Experiment Station.

New Method of Estimating Wildlife Abundance from Livetrapping Data

Viable population estimates or indices of abundance are essential to many ecological investigations. Most wildlife species can not be counted directly because of their secretive behavior. Capture-recapture methods have long been used to estimate the abundance of such species as cottontails, squirrels, and other small mammals. Numerous estimators have been proposed for use with livetrapping data, most of which assume some combination of random, uniform, or constant probability of capture. Wildlife specialist William R. Edwards has used 22 years of data from cottontails livetrapped at Allerton Park to evaluate methods of estimating abundance from capture-recapture data. He rejected the usual methods of population estimation because probability of capture is not random, uniform, or constant.

Frequency of capture typically follows the geometric, and frequently the negative, binomial distributions. Edwards' current study demonstrates that past difficulties with the geometric and negative binomial estimators have been caused by sampling intensity bias. Higher rates of capture than are typically obtained are needed to minimize that bias.

Edwards found that two of the geometric estimators had biases that tend to offset each other when the estimators are combined. He has proposed a combined estimator as the "best" one for use with livetrapping data, provided the data approximate the geometric distribution. Be-

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cause livetrapping data usually do approximate that distribution, the combined estimator should be very useful in population studies of rabbits and other small mammals.

Edwards cautions that in any livetrapping study what is being estimated is the number of animals that have had a positive probability of capture at some time during the trapping period. This estimate is not necessarily an estimate of the number of individuals on the area at any given time or even of the number whose centers of activity fall within the study area. It is not legitimate to relate population estimates to the area trapped in order to estimate the population density of animals on the area trapped. Livetrapping can only estimate the individuals that used the area during trapping. The reasons for rejecting estimators often used in wildlife population studies also hold for estimates based on visual observations of color-marked or tagged animals, because those animals do not have the required random, uniform, or constant probabilities of observation.

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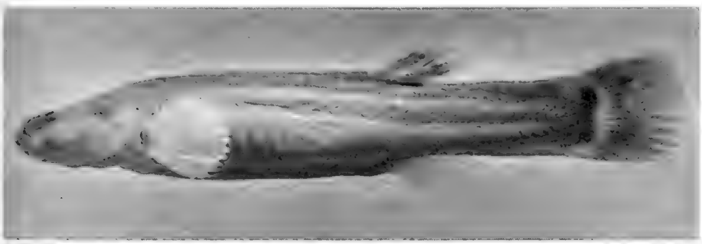
The Spring Cavefish

The cavefishes make up a family of only six known species, all occurring in the eastern half of the United States. All but two of them are eyeless, unpigmented, small fishes confined to streams in the deep recesses of caves and known to visitors of commercialized caves. The exceptions are two species in the genus *Chologaster* (meaning mutilated belly in reference to the absence of pelvic fins). One of them is pigmented, eyed, and lives in surface waters on the Costal Plain of the Southeast. The other is intermediate in almost every way between surface-dwelling fishes and the true cavefishes. It is known from a few springs and caves in Tennessee, Kentucky, southern Illinois, and extreme southwestern Missouri. It is the subject of a new Survey publication entitled "A summary of the life history and distribution of the spring cavefish, *Chologaster agassizi* Putnam, with population estimates for the species in southern Illinois." The paper was written by Survey ichthyologist P. W. Smith and N. M. Welch, a physician on the staff of a Dallas, Texas, hospital. Copies are available upon request to this agency.

Since this three-inch, semi-translucent fish bridges the gap between an existence above ground and in subterranean waters, it is a curiosity often sought by collectors. Several state conservation departments and the U. S. Department of Agriculture Forest Service became concerned that its numbers might be seriously depleted from over collecting. The Forest Service in 1973 employed Dr. Welch to census the numbers of this fish in several springs in the LaRue-Pine Hills Ecological Area of Union Co., Illinois. This he did by dipnetting specimens at night in springs and marking them with an injection of tattooing ink. Then by using a mathematical formula called the Petersen Index, he could calculate the probable number of individuals present based on the proportion of marked to unmarked fish taken on each visit. He found that in eight springs studied the number of fish ranged from one to 302 individuals for a probable overall total of 785 ± 314 fish — thus fewer than 1,000 individuals in the gene pool.

All known aspects of the life history of the species were summarized in the report. It was found that breeding occurs underground in winter, that the 80 to 285 eggs



An adult spring cavefish from a spring along Big Creek, Hardin Co., Illinois. (Photo by L. M. Page)

produced by one female are almost two mm in diameter, that the fish grows on an average of 10 to 20 mm per year, that it rarely attains an age of three years, and that in springs it feeds primarily on one kind of amphipod but in caves is strongly cannibalistic (caves have a very limited food supply). Many facets of its reproductive cycle are still unknown. It emerges into springs at dusk but usually retreats underground just before daylight. It is most often found when springs have heavy outputs such as after rains. Its eyes are so poorly developed that it relies on smell and touch to discern its food. It has evolved an ability to withstand without acclimation higher water temperatures, which offers some protection to a little fish sometimes swept into warm surface water by copious spring flow. The spring cavefish is superbly well adapted to a very difficult way of life.

Turfgrass Insect Problems

Insects infesting home lawns have usually been either the sod webworm, *Crambus trisectus* or the annual white grub, *Cyclocephla immaculata*. The sod webworm occasionally is a serious problem in late July and August especially in the central and northern areas of the state. The buff-colored moths lay eggs while in flight on the best fertilized and watered lawns in an area. The first generation appears in June and there is never enough of a population to cause damage. The second generation in late summer can be damaging. The larvae damage the grass by cutting shoots off about ⅛ inch above the crown rather than 1½ to 2 inches as recommended for proper mowing of a lawn.

Annual white grubs are increasing in both numbers of lawns infested and the area of Illinois in which it is being commonly found. The grubs are white with brown heads and C-shaped, and feed on the roots of bluegrass causing the sod to be severed from the soil surface. Counts of 12 to 50 grubs per square foot can be found in most lawn areas from about Interstate 70 on the south to Interstate 80 on the north across the state from east to west. Tan, half-inch long, adult beetles emerge in June from the sod and soon lay eggs. The eggs hatch in July and damage can be observed, if grubs are present, after mid-August until early November. The grubs overwinter below the frost-line deep in the soil.

Two insects which were found in damaging numbers in golf course turfgrass during 1977 included a sod webworm, *Crambus teterrellus* commonly called bluegrass webworm and a small grub, *Ataenius spretulus*. The bluegrass webworm was severely damaging the bentgrass golf greens by feeding on the roots as a soil insect. The *A. spretulus* has been observed during the past four years feeding on the roots of bentgrass and annual bluegrass commonly found in the fairways. Numbers of both bluegrass webworm and *A. spretulus* were very high on some golf courses. As many as 200 or more webworms per square foot were found under bentgrass sod in western Illinois. *Ataenius* grubs numbering over 300 per square foot were found in the Chicago area.

Chemical control evaluations continue to be done for control of grubs and webworms. There are many labeled and effective sod webworm control insecticides for use by the home lawn owner and managers of other turfgrass areas. Many insecticides are very effective for grub control if applied in late summer or fall. But only two are labeled at the present time with one, diazinon, being the only one available in garden centers and other stores selling pesticides to homeowners.

Illinois Mollusks

In May Professor Emeritus Max R. Matteson of the University of Illinois deposited his personal collection of naiad mollusk shells in the permanent research collections of the Illinois Natural History Survey. His specimens, described by several biologists as the finest state collection of mussels in existence, is being put in order by one of his former students, Mrs. Liane Suloway. His material will be referred to as "The Max R. Matteson Mollusk Collection."

Dr. Matteson joined the Zoology faculty in 1947 and soon thereafter embarked on a quantitative survey of the mussel fauna

Dr. Max R. Matteson. (Photo by Gliessman Studios, Champaign)

of the inland rivers of Illinois. Throughout the 1950's and well into the 1960's, he and a research assistant conducted transects of streams at three, seven, and 15-mile intervals on 22 different streams in the state. The collecting sites were randomly selected on quadrangle maps the night before each visit, but the precise transect made at places judged typical for the stream with access and a riffle or raceway shallow enough to be worked from one bank to the other. Sight from above the water, snorkeling, and groping were employed, depending on which method was appropriate. Dr. Matteson and assistant worked steadily at each site for three hours before moving to another so that the number of each clam species could be expressed in man-hours of effort.

Since dead shells could be transported downstream by cakes of floating ice, only living animals were taken. Each had to be boiled, fleshed, and thoroughly scrubbed. The dried shells were subsequently sorted and identified. Meticulous field notes were recorded, and a sketch of each site drawn. If no shells were found after three hours, the station was still recorded, and the reasons for the absence of mollusks noted. The field notes list numbers of each species found at every station.

The stream collections represent 225 sites. The Illinois River was, of course, too deep to be worked from one bank to the other, and another river in southwestern Illinois was avoided because Dr. Matteson didn't like snakes! Collections are available from several stations now inundated by large reservoirs such as Shelbyville and Carlyle, and all of them were made before the peak of the present environmental crisis. Environmental degradation was relatively minor in many parts of the state in the 1950's. Other samples are present from ponds in Illinois and streams in Indiana and Michigan. The collection is of enormous value in providing quantitative baseline data that enable reconstruction of native habitats and their degree of deterioration at that time. It will provide priceless information for environmental impact statements and will be an important resource for future ecological studies of our aquatic environments.

Wandering Weevils

The detection in Illinois in May 1977, of the imported crucifer weevil, *Baris lepidii,* was unusual in the sense that the insect was first found established in the Western Hemisphere in Illinois. It was not the first time that an immigrant species of weevil has found its way to the state. Since the period of the Civil War, at least one species per decade on the average, of these wandering weevils has become established in Illinois and many are of concern to agriculturalists of the state.

The cabbage curculio, *Ceutorhynchus rapae,* another European pest of cruciferous crops, including cabbage and horseradish, was first detected in the United States in New England in 1855. A specimen in the Illinois Natural History Survey was collected in the central Illinois city of Bloomington on May 15, 1882. Also from Europe are three species of *Otiorhynchus, O. ovatus,* the strawberry root weevil, *O. sulcatus,* the black vine weevil, and *O. rugosostriatus,* the rough strawberry root weevil. These damaging weevils feed as

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larvae on the roots of a variety of cultivated plants and they are frequently received at the Illinois Natural History Survey for identification and for recommendation for control measures. Several of the *Otiorhynchus* species were detected along the eastern shore of the United States from 1835 to 1876, and one of them, the strawberry root weevil, was taken at Urbana as early as 1891.

Perhaps the most damaging European import has been the alfalfa weevil, *Hypera postica*. The eastern strain of the alfalfa weevil was detected in Maryland in 1952. By 1964 it had entered Illinois, and it is now well established throughout the state. Pest management of the alfalfa weevil is a matter of serious concern to growers of alfalfa in Illinois.

Japan has also been a source of pest species. Since 1940, three such Oriental weevils, *Calomycterus setarius*, the imported longhorned weevil, *Cyrtepistomus castaneus*, the Asiatic oak weevil, and *Pseudocneorhinus bifasciatus*, the Japanese weevil have become established in Illinois. The most recent of these to arrive in the state, the Japanese weevil, was identified by Survey entomologist, John K. Bouseman, upon its detection at Murphysboro in the southern part of the state in 1976. In addition to feeding as adults on the foliage of a wide variety of cultivated plants, the imported longhorned weevil and the Asiatic oak weevil frequently enter households in large numbers, thus giving them status as a general nuisance, and are very frequently received at the Illinois Natural History Survey for identification.

With the advent of rapid air transportation, we may expect to see more of these unbidden guests arrive in the state. Formerly such tramp species had to undergo the quarantine of a long voyage. Now they can travel long distances in a few hours. The presence of a large reference collection at the Illinois Natural History Survey helps to insure that any such future immigrant will be quickly identified after its detection in Illinois.

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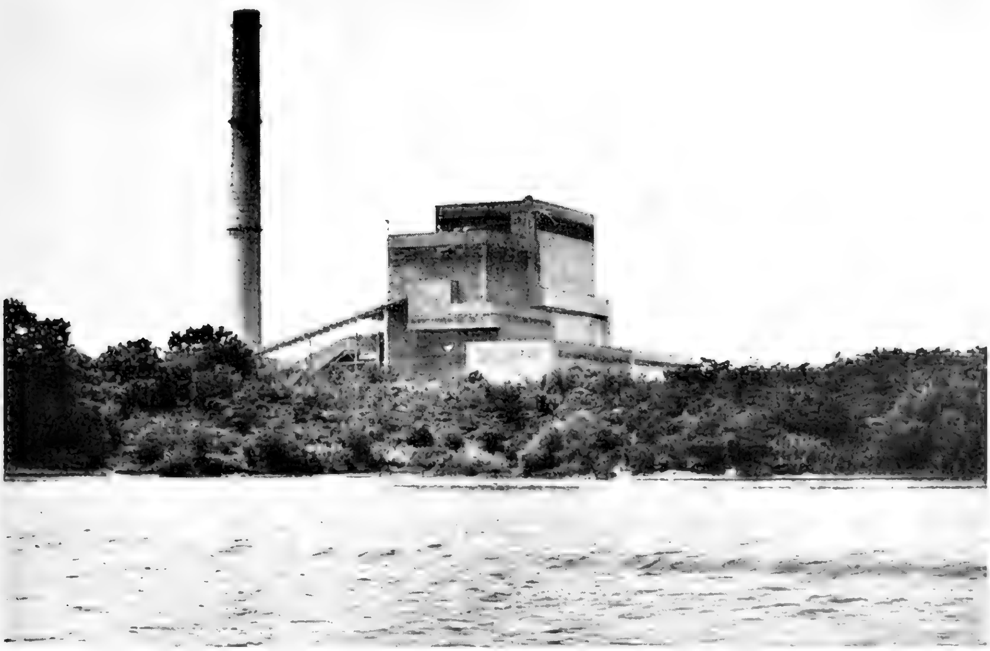
Cooling Lake Study

The Illinois Natural History Survey has signed a research contract with Central Illinois Public Service Company (CIPS) to investigate the environmental effects of the CIPS Coffeen Power Station on Coffeen Lake, located 8 miles southeast of Hillsboro. The 3-year study will include coordinated investigations of the physical, chemical, and biological aspects of this power plant cooling lake. Individual research projects included within this study will be investigations of water quality, aquatic macrophytes, phytoplankton, zooplankton, benthos, fish, and trace metals in the biota.

Drs. John Tranquilli and R. Weldon Larimore, principal investigators of the study, said that the investigation is designed to determine whether Coffeen Lake and Shoal Creek, its receiving stream, are environmentally acceptable in terms of supporting shellfish, fish and wildlife, and recreational uses consistent with good



Central Illinois Public Service Company power plant on Coffeen Lake. This cooling lake is to be the subject of a 3-year study.

management practices. Jim Buckler will be the project leader and will be stationed at the field laboratory, located in Taylor Springs, Illinois.

It is hoped that, at the end of this 3-year study, recreational facilities may be developed through the cooperation of CIPS and the Illinois Department of Conservation.

Effects of Drought on Plant Membranes

The membrane is an essential part of all living cells, and the plant cell is no exception. The membrane (plasmalemma) forms the major barrier between the interior of the cell (protoplasm) and the external environment. The biological membrane is semipermeable (it permits the passage of some molecules but not others), allowing water to enter the cell at a faster rate than most solutes can enter. In the root system, the membranes control the uptake of water and nutrients, and only through the action of a semipermeable membrane can the proper water status be maintained. Within the plant, membranes also control the movement of solutes and water, and without this control mechanism the plant could not survive.

A plant is composed of 80-90 percent water. The movement of water from the roots to the leaves is extremely important, because the nutrients for proper plant growth are carried along in the water. Most of the water that is taken up by the plant is lost through the leaves by transpiration. The water status of the plant is a function of water uptake and water loss, and certain environmental factors influence this ratio by changing the behavior of membranes.

Claus Grunwald, plant physiologist at the Survey, is studying the effects of water stress (drought) on plant membranes, especially as the stress factor might change the chemical makeup of membranes. Biological membranes are composed of proteins and lipids at about a 1:1 ratio. A number of environmental factors produce small changes in the lipid component of membranes, and it is believed that these slight changes have a significant influence on the behavior of membranes.

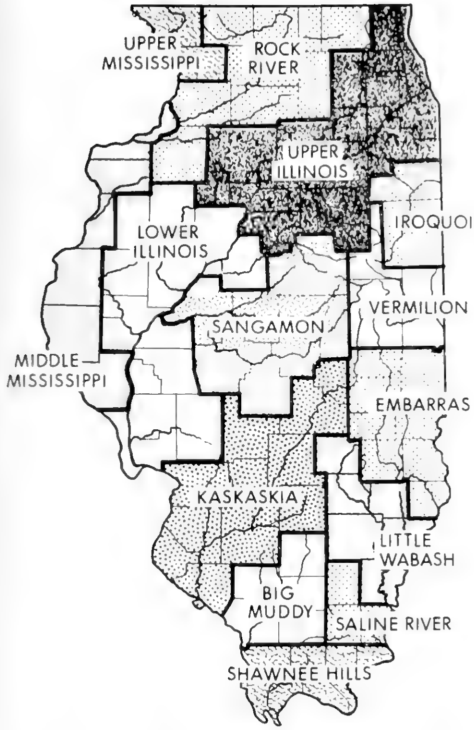
For example, low temperatures reduce the uptake of water, and this reduction is due to a decrease in membrane permeability. It is thought that a change in sterol composition and fatty acid saturation occurs as the growing temperature is changed. Whether similar changes occur under drought conditions is presently not known, but many cellular activities are very similar under water and temperature stresses. An understanding of any changes in plant membrane behavior or chemical composition resulting from drought could help us in minimizing the effects of drought on field crops and other plants.

The Gray Squirrel in Illinois

The flora and fauna present in Illinois when the first white settlers moved north and westward across the Ohio River have undergone drastic changes during the past 175 years. This change is particularly true for the gray squirrel, a species adapted to large expanses of old-growth hardwood forests. Extensive clearing of the virgin forests following white settlement led to the virtual disappearance of gray squirrels in many of the central and northern counties early in this century.

Survey wildlife biologists C. M. Nixon, S. P. Havera, and R. E. Greenberg have documented these changes in gray squirrel abundance in a new publication, "Distribution and Relative Abundance of the Gray Squirrel in Illinois," published by the Survey as Biological Notes No. 105. Copies of this publication may be obtained free by writing to the Chief, Illinois Natural History Survey.

To determine the present status of the gray squirrel, Nixon and his co-workers divided Illinois into 14 watersheds (see map) and in each watershed contacted cooperators thought to have knowledge of gray squirrel abundance. Cooperators were requested to indicate the townships presently "occupied" by gray squirrels and to indicate their relative abundance as: *Common* — frequently shot or seen, *Scarce* — shot or seen every year but only in low numbers, *Rare* — shot or seen infrequently (every 2 or 3 years), or *Absent*. Supervisors of urban parks were also contacted in all the major cities of Illinois to de-



The major watersheds of Illinois, used to delineate the present distribution and relative abundance of the gray squirrel.

termine the urban distribution of gray squirrels.

Gray squirrels were found to be generally distributed throughout the Shawnee Hills, Saline River, and Big Muddy watersheds, and to be common in the southern portions of the Kaskaskia, Little Wabash, and Embarras basins. In the remaining watersheds, however, gray squirrels were found to be widely scattered, with large areas of unoccupied range in each watershed.

Why has the gray squirrel fared so poorly in this century while the fox squirrel has increased in abundance during the same period? The answer lies in the differing habitat requirements of each species. Gray squirrels favor extensive forests of mature hardwoods, while fox squirrels are adapted to woodlots, hedgerows, and relatively young and open forests. Thus, the transformation of Illinois from a wilderness to a modern technological society has favored the fox squirrel, because much of the forest cover present in Illinois in 1800 has been destroyed (declining from 15.25 million acres to the present 3.7 million acres or less). There is a significant relationship between the percentages of gray squirrels killed in each county and the percentage of each county that is forested.

What does the future hold for the gray squirrel in Illinois? The human population of the state is predicted to increase from the present 11 million to nearly 14.5 million by 1990. This increase in human population will place even more pressure on the already distressed forest ecosystems. Gray squirrels are expected to continue to decline in numbers in the Upper Mississippi, Rock River, Upper Illinois, Sangamon, Vermilion, and Iroquois drainage basins. They are also expected to experience further declines in the upper reaches of the Kaskaskia, Little Wabash, and Embarras basins if stream channelization and conversion of forests to tillable land continue at the present rates. Gray squirrels should be relatively secure in the lower portions of these basins as well as in the Big Muddy basin, the Shawnee Hills, and portions of the Saline River basin. However, as new water impoundments are created, more acres are strip mined for coal, and towns and cities expand, gray squirrels will become locally scarce or absent even in these extensively forested basins.

Progress Report on Introduced Lady Beetles

A large population of the seven-spotted lady beetle, not native to North America but found throughout much of Europe, Asia, and India, was located in New Jersey in 1974. In 1975 Survey entomologist Clarence White began receiving shipments of these ladybugs from the U.S. Department of Agriculture, and he traveled to New Jersey to collect beetles. Like most species of lady beetles, these feed on other insects and their eggs and help to control insects that are harmful to agricultural crops and ornamental plants. These beetles, however, are about twice the size of the native ladybugs, and they feed heavily on aphids.

White has released thousands of these lady beetles at several locations in Cham-

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paign County in 1975, 1976, and 1977. Last November, 13,000 adult beetles were placed in overwintering cages in the forestry plantation south of Urbana. The cages have openings which allow the insects to disperse naturally in the spring.

Searches of the 1975 and 1976 release sites have not revealed any evidence that the beetles are reproducing and establishing a permanent population here. However, White did find evidence of reproduction in 1977 near a release site in the Salt Fork River Forest Preserve near Homer and at another site near Mayview. The fact that larvae were observed in the summer and adults in the fall is encouraging, but is not proof that they have established a population here.

By conducting a selective-breeding program in the laboratory, White has obtained, in nine generations of beetles, a strain that produces not one but several generations each year. This lady beetle breeding and release program is only one of many on-going attempts by Survey researchers to find natural, in addition to chemical, means of controlling harmful insects.

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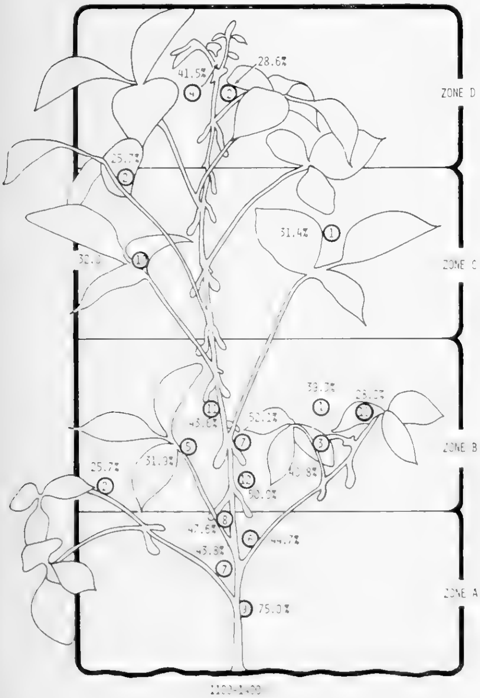
Soybean Spiders

Spiders are receiving considerable attention as potentially important predators of arthropod pests of agricultural crops because of increased interest in the development and use of integrated pest-management systems. However, reports quantifying spider populations, showing colonization rates, and listing prey preferences of the dominant spider species in row crops are lacking. Entomologists C. D. LeSar and J. D. Unzicker, with support from the Section of Economic Entomology and the Illinois Agricultural Experiment Station, undertook a study of spider species composition, population densities, and vertical distribution in soybeans in order to provide information on these predators in soybean fields.



Locations of the 12 most abundant spider species on soybeans during the 1100-1400 time period with percentages of each species present. (Diagram by Lloyd LeMere, Survey artist)

Over 4,100 spiders, representing 77 species, were collected in five fields during two seasons. Colonization of the fields began in mid-June, after insect colonization had begun, and continued until mid-August. Early colonizing spiders during 1975 suffered high mortality rates because the small soybean plants offered little protection from heavy rains. Only 13 of the 77 species collected during the 1975-76 growing seasons became firmly established on the soybean plants.

The data from three combinations of fields and/or years were analyzed and compared for species diversity. Diversity was higher in 1975, when a very wet growing season suppressed the dominant species, *Tetragnatha laboriosa,* causing a greater evenness of distribution among the remaining species in the population. In 1976, when a relatively dry summer allowed the build-up of the dominant spider, the spider species in the total sample became uneven in their abundance, causing the diversity to decline. Spider diversity was high when adjacent fields sampled in different years were compared, while widely separated fields sampled the same year had similar values. This suggests that differences in habitats adjacent to the soybean fields (e.g., woodland versus native grasses) played a major role in species composition.

Species diversity was greatest after the soybean plants matured and the foliage provided the greatest number of niches for the spiders and prey. Population densities peaked during early September and then fell rapidly as the soybean plants reached senescence.

The soybean plant was divided into four vertical zones of about 250 mm each for stratified sampling. Sampling showed that two-thirds of the entire spider population was located on the lower one-half (Zones A and B) of the plant during any time period of the day. There was a great deal of species shifting which is likely determined by heat and humidity stress, as well as availability of prey. A two-way analysis of variance indicated that the six most common species had significant differences in location of the population between zones and/or the different time periods of the day. The locations of the 12 most abundant spider species on soybean plants between the hours of 11:00 a.m. and 2:00 p.m. is shown in figure.

Spiders are indiscriminate predators which feed on beneficial as well as insect pest species and, with the exception of *T. laboriosa,* do not reproduce in soybean fields. Thus the spider population in a given field cannot respond numerically to increases in prey densities. However, there may be a functional response to changes in prey densities in which additional spiders are recruited from areas adjacent to the fields. The authors recommend additional research to explore the role of these predators in agrosystems including: (1) determination of spider species commonly found in major agricultural crops, (2) studies on the migration and dispersal patterns of the major spider species, and (3) laboratory feeding studies to determine the potential impact on insect pest species.

Lake Michigan Diversion

Ever since the turn of the century, a major part of the water in the Illinois River has come from Lake Michigan. Currently, lake water is diverted into the Illinois Waterway at Chicago at an average rate of 3,200 cubic feet per second (cfs). By comparison, the average flow of the Illinois River at Kingston Mines (182 miles downstream) is 9,000 cfs or less during half the year.

Now much more water may be on the way and the Natural History Survey will help evaluate the effects. Congress has authorized a temporary one-year tripling of the Lake Michigan diversion rate to 10,000 cfs, in order to determine how increased diversion would affect the levels of the Great Lakes and water quality and flooding in the Illinois Waterway.

The Chicago District of the U.S. Army Corps of Engineers has asked the Aquatic Biology and Wildlife Research Sections of the Natural History Survey: (1) to provide a preliminary assessment by December, 1978, of the expected effects of increased diversion on fish, wildlife, and vegetation in and along the Illinois River; (2) to conduct a baseline survey of existing biological conditions in and along the Illinois River; and (3) to monitor the biological effects of the temporarily increased diversion, which is scheduled to begin in the fall of 1979. Aquatic biology staff, under the supervision of Richard E. Sparks and Kenneth S. Lubinski, are reviewing available literature and are also computerizing and analyzing previously unpublished data for the preliminary assessment.

Between 1931 and 1972 D. H. Thompson and W. C. Starrett conducted fish population surveys in the Illinois River and its bottomland lakes. Their surveys spanned a period in which Lake Michigan diversion varied and in which there were several floods and droughts in the river basin. Present survey staff are continuing and replicating these studies. Information about relationships between fish populations, water levels, and river flow should make it possible to predict some of the effects of increased diversion on fish.

Wildlife biologists Frank Bellrose and Stephen Havera are supervising studies of vegetation and wildlife along the Illinois River, including water level tolerances of several species. Inventories of ducks, geese, swans, eagles, herons, egrets, shorebirds, beaver, and muskrats are being expanded and updated.

Aerial photo showing some of the multiple uses of the Illinois River: scenic bluffs to the left are part of Starved Rock State Park, barges and a tug approach the Starved Rock lock and dam from downstream. (Photo by former Survey photographer, W. D. Zehr)

Wildlife researchers are also measuring the contours of the bottomland lakes and sampling and mapping the plants which grow in bottomland forests and mud flats along the river. A lake's contours influence the degree to which increased diversion will flood the adjacent forests and mud flats. Deer, squirrels, raccoons, and other valuable game animals inhabit the bottomland forests, along with ecologically important nongame species. Mud flats provide moist soil food plants for migratory shorebirds and waterfowl, such as pintails, widgeon, gadwall, and teals.

What happens in the Illinois valley is important to the entire state. Natural resources in the river valley include a commercial fishery, bottomland forest, prime farmland, private duck hunting clubs (about 60,000 acres), private goose hunting clubs, nature preserves, natural areas, state parks, conservation areas, and federal wildlife areas. A complete and accurate evaluation of the effects of increased diversion is both economically and environmentally essential to Illinois. The data now being gathered and analyzed should make this evaluation possible.

Soybean Mosaic Virus

Soybean mosaic virus (SMV) occurs wherever soybeans are grown and, from a global perspective, is probably the most common and important virus attacking soybeans. The impact of SMV on soybean yield varies depending on locality, soybean cultivar, and particular strain of the virus. The time of inoculation is directly and positively correlated with yield quality and quantity. Survey entomologist, Michael E. Irwin, and University of Illinois virologist, Robert M. Goodman, both of whom hold joint appointments and postdoctoral fellow, G. A. Schultz, have recently found large

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yield reductions and decreased seed quality in soybeans inoculated with a severe strain of SMV soon after emergence. Later inoculations produced less drastic results.

SMV is transmited from generation to generation through the seed and is spread within and between fields by winged aphids. The only important field sources of SMV are soybean plants grown from infected seed, and the percentage of SMV infected seed in seed lots in central Illinois is very low. Therefore, the amount of primary inoculum available for spread is currently minimal.

Timing and abundance of alate aphids is a critical factor in the spread of SMV. Irwin, and Susan E. Halbert, a graduate student, have found more than 60 species of aphids landing in central Illinois soybean fields each year. Since aphids do not colonize soybeans in Illinois, insecticide sprays are ineffective against field spread of SMV. Only about six of the more abundant species are important as vectors of SMV in Illinois. Irwin has monitored aphid flight activity in soybeans for the past four years. Each year the temporal pattern was distinct and abundances shifted between years.

Because SMV reduces yields and lowers seed quality most severely when it infects soybean plants during early vegetative stages, late spring to early summer flights of aphid vectors are very important to SMV spread.

Although SMV is a limiting factor in soybean production in some areas of the world, it is not currently an important disease of soybean in central Illinois because seed lots have a very low percentage of SMV infected seeds and aphid flights have been sporadic. If aphid flights become heavy and timely for several seasons in a row, this disease could become increasingly more important in central Illinois. Monitoring aphid flight activity and insisting on a minimum standard of acceptance for SMV infected seed in certified seed lots are two ways of helping to predict and prevent possible SMV epidemics in the future.

The work undertaken by this team of researchers has been supported by the International Soybean Program (INTSOY) through the Agency for International Development, an Illinois Agricultural Experiment Station competitive Hatch grant, and the Illinois Natural History Survey.

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Fall Freezing Affects Plant Disease

The past two winters in the Midwest set new records for severity. Are we in for another bitter cold winter or will we be spared such hardship this year? Unfortunately, the weather in Illinois is unpredictable, regardless of the Farmer's Almanac and the color bands on the "wooly bear" caterpillars!

Much of the damage caused by the record snow, ice, and low temperatures became apparent during the past two springs in the form of crumbling highways, burst water and sewer lines, cracked masonry, etc. A more subtle type of winter damage that few people recognize, however, occurred on many of the trees and shrubs in Illinois. This damage can be seen as an increase in the frequency of certain types of plant disease.

Fall temperatures in 1976 decreased steadily to very low levels and the extreme cold persisted into mid-February. Extreme low temperatures, such as the $-20°$ to $-30°$ F readings recorded in January of 1977, caused the death of fruit buds, trunk cracks on sugar maple and london plane trees, and the death of stems on woody species not native to the area and on those on the northern edge of their natural range, such as sweet gum trees in central Illinois. Most of this damage was due to actual freezing and physical injury caused by ice crystal formation in plant cells. The injury was apparent at the time of new growth in the spring of 1977.

The winter of 1977–1978 was quite different, as was the effect on woody plants. Temperatures were below normal for most of the fall, winter, and spring but did not reach the extremes of the previous year. However, plant damage was often more severe. The main cause of this extensive damage was a hard freeze to near zero in early December 1977 after an extended period of relatively mild weather.

Trees and shrubs cold harden under slowly falling temperatures and, when fully hardened, may withstand record low temperatures without injury. If hardening is delayed by mild weather, a severe drop in

Basal canker with fruiting bodies of the fungus *Tubercularia* on stems of tallhedge weakened by freezing. (Photo by Dr. D. F. Schoeneweiss)

temperature to below freezing can result in frost collars, bark splitting, and dieback of stems. Even if tissues are not killed, freezing temperatures can weaken stem tissues and cause normally resistant plants to become susceptible to attack by many stem-infecting canker fungi. A sizable increase in the appearance of stem cankers on several tree and shrub species this past spring reflected the freezing stress that occurred from the hard freeze last December.

The dramatic influence of sublethal freezing stress on disease susceptibility of dormant but not fully cold hardened woody stems has been reproduced artificially in controlled freezing experiments by Survey plant pathologist D. F. Schoeneweiss. Plants frozen and inoculated with stem canker fungi that do not attack non-stressed plants showed disease symptoms typical of those observed under field conditions. Unfrozen inoculated plants and plants frozen but not inoculated remained healthy and were indistinguishable from untreated plants.

These results confirm the relationship between freezing stress and many common stem canker diseases and help explain the sudden outbreak of certain diseases, such as basal stem cankers on upright euonymus, tallhedge buckthorn, and red-twig dogwood, that occurred this year.

Unfortunately, little can be done to prevent this type of damage except to plant sensitive species in sites protected from extreme exposure and to avoid practices such as late-season watering and fertilizing or the use of outdoor lighting, which may delay the hardening of woody ornamentals. The appearance of stem canker damage on many woody species should be considered symptoms of stress conditions rather than plant diseases that can be controlled with fungicide sprays.

The Heron Report

The most recently published paper in the Survey's series on Illinois bird populations is *Illinois Birds: Ciconiiformes.* It covers the herons and related species and presents the histories of the Illinois populations, so far as they are known, as well as recent population figures for the various species. The paper also contains quantitative information on migration, nesting, and feeding habits of herons in Illinois. As with all the papers in this series, this one is based on a bibliography of about 7,000 titles, previously unpublished data from numerous contributors, and the field work of Jean and Richard Graber, who compiled the data.

Between 1973 and 1976 an effort was made to locate all the major heron colonies in the state in order to see how well the populations were surviving. Though historical records were fragmentary, the recent census data indicated that heron populations have undergone two kinds of change — (1) a relatively slow long-term decline and (2) a much more rapid recent decline, particularly noticeable in southern Illinois. Possible causes of the population declines are discussed, and areas of further study are recommended in the report.

A serious problem for students of natural populations, and one very pertinent to the herons, is the general lack of information on "normal" fluctuations to be expected from one year to the next. That kind of information is becoming more and more difficult to acquire because the general environment has become so unstable. That instability is exemplified by habitats that are available one year and gone the next, and by food sources clean and dependable in one decade, but in a few short years, dangerously polluted.

There is some evidence that at least the great blue heron and great egret in Illinois are being harassed by hydrocarbon pollution. Egg shells from two colonies on the Mississippi River were very thin by comparison with those of pre-1940 eggs.

An important next step in research on Illinois herons would be comparative studies of the pesticide relationships and productivity of herons in northern Illinois (where populations are surviving better) with those in the south.

Single copies of *Illinois Birds: Ciconiiformes*, Biological Notes No. 109, are available on request. Write to the Chief, Illinois Natural History Survey, 172 Natural Resources Building, Urbana, Illinois 61801.

Adult yellow-crowned night heron, from a drawing by Beverly Sanderson. This bird has a bluish gray body and is about 50 cm tall.

Pelleted Baits for the Black Cutworm

The black cutworm, *Agrotis ipsilon,* is a serious pest in Illinois cornfields, and its attack results in an average of 58-percent loss of plants and a 42-percent loss of yield in some fields. Survey entomologist Ralph Sechriest had found that insecticides in the form of pelleted baits were as effective as sprays in controlling black cutworms in greenhouse and small-plot field experiments. Consequently, he and entomologist Dan Sherrod investigated the effectiveness of pelleted baits under different soil moisture conditions in the greenhouse and as emergency treatments for the control of black cutworm larvae in large field experiments.

Illinois cornfields with natural infestations of third- and fourth-instar black cutworms were selected for the experiments. Commercial formulations of pelleted baits, consisting of standard carrier mixtures of apple pomace, cornmeal, wheat bran, and molasses combined with an insecticide, were used. Baits were broadcast by hand in late May or early June on plots measuring 31 x 31 meters. Pesticide performance was evaluated by comparing the original stand of healthy plants with the number of plants remaining 3 weeks after treatment. Each experiment was replicated three times.

Within the center of each plot, five 15-meter rows, each separated from the others by a row on each side, were staked so that a known number of plants in each plot could be compared. Natural infestations of black cutworm larvae varied greatly, as did plant stand counts, from one plot to another. Thus, comparisons were made between the plant stand counts in the staked corn rows when the treatments were applied and at 1, 2, and 3 weeks after treatment.

The effects of two levels of soil moisture on black cutworm control with pelleted baits and granules were examined in the greenhouse by using wooden flats (plots) with 20 corn plants in each. Treatments equivalent to 1.12 kg of active ingredient per hectare were applied to three replicates of each experiment at the time of planting. Some flats were watered so that the soil surface was always moist, while others were watered only enough to keep the seedlings from wilting. Three fourth-instar black cutworms were released in each flat 3 weeks after planting, and 1 week later two

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fourth- and three fifth-instar cutworms were released in each plot. Counts of healthy seedlings were made at the time of each infestation and 1 week later.

Sechriest and Sherrod found that in the field the standard control practice of applying toxaphene spray as a band over the row was less effective than the broadcast fonofos bait. Carbaryl 5-percent bait and biothion 2-percent bait broadcast at the rate of 0.56 kg of active ingredient per hectare protected corn seedlings as well as the same baits broadcast at double that rate. Biothion 2-percent, carbaryl 5-percent, chlorpyrifos 2-percent, fonofos 4-percent, methomyl 1-percent, and trichlorofon 5-percent baits provided good control of the black cutworm larvae in 3 years of field experiments.

Soil moisture affects the control efficacy of pelleted baits under field conditions. Carbaryl 5-percent bait was found not to have as good residual effectiveness on moist soil as on dry soil in the greenhouse experiments. Some moisture must be present to make the dry pelleted bait acceptable to the larvae, but generally the humidity in the air or a slight dew was sufficient to soften the pellets. In addition, the carriers tend to attract moisture. Since black cutworm larvae typically feed and rest only in moist soil, during extremely dry conditions larvae remain 5–8 cm deep in the soil and may not respond to the pelleted baits. Conversely, moist soil with larvae at or near the soil surface appears to aid control with such baits. This moist soil condition is typical of most Illinois fields when corn seedlings are emerging, and excellent control can be expected under these circumstances.

Damage to seedling corn in the field can range from slight to extensive, and the cutting of 30–50 percent of the plants in a cornfield by black cutworm larvae is common. However, as much as 40-percent recovery or regrowth of cut plants is possible. The closer to the time of seedling emergence the treatments were applied, the greater was the protection provided. The preferred control recommendation by Natural History Survey and University of Illinois extension entomologists is carbaryl 5-percent pelleted bait, and good control of black cutworm larvae has been achieved by Illinois farmers except under very dry conditions.

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Mail Carrier Pheasant Census

One method employed by biologists to monitor the relative abundance and distribution of pheasants in Illinois is that of soliciting volunteer assistance of the rural letter carriers in recording pheasants observed while delivering mail. The first Rural Mail Carrier Census (RMCC) was conducted in Illinois during five consecutive days in April in 1958 and has been repeated at five-year intervals. Wildlife biologist Richard E. Warner has recently released data from the 1978 RMCC which encompassed the 74 northernmost counties of the state. Self-maintaining populations of pheasants in Illinois are known only in these counties.

Eighty-eight percent of the 1,178 census cards mailed to rural letter carriers in 1978 were returned and found usable (89 percent were returned and found usable in 1973). A total of 366,005 miles were tallied in 1978, about 15,000 miles more than in the previous count. The number of pheasants observed per 100 miles of driving averaged 0.8 in 1978, compared with 4.9 in 1973, 5.5 in 1968, 9.9 in 1963, and 7.6 in 1958. Thus, the number of pheasants recorded in 1978 represents a decline of 83 percent over the five year period since 1973.

Counties that were among the top 15 in 1973 but are not on this list in 1978 include Macon, McLean, Iroquois, Moultrie, DeWitt, Kankakee, Vermilion, Champaign, Piatt, and Douglass. The northernmost two tiers of counties, broadly classified as a mixed livestock and dairy region, presently rank among the highest with respect to numbers of pheasants counted, a position that has been held in recent decades by the east-central cash grain belt. The top

Cock pheasant in roadside habitat. (Photo by Larry M. David, Department of Conservation)

ten counties are now Macon, Winnebago, Carroll, Lee, Stephenson, Kendall, Woodford, DeKalb, Will, and Ogle. Declines in pheasants observed over the past five years were evident for all of the top 15 counties censused in the 1978 RMCC.

Two factors which have most contributed to the depletion of populations of pheasants from 1973 to 1978 in Illinois have been the continued expansion of row crop farming, resulting in less prime habitat for reproduction, and severe winter weather, particularly where protective cover on the winter landscape is scarce. The RMCC indicated declines of 80 to 96 percent since 1973 in Champaign, Ford, McLean, and Iroquois counties. Declines of this magnitude have been directly attributed to severe winter storms in 1976–77 and 1977–78 on areas in these counties that are monitored as a part of ongoing investigations. Evidence of this sort, in conjunction with the fact that the ringneck presently appears in greatest numbers where protective winter cover is most abundant, as in the northernmost tier of counties, suggests that the decline since 1973 is largely the result of severe storms during the previous two winters.

Malaysian Prawns in Illinois

Aquatic scientists at the INHS and the Urbana campus of the University of Illinois recently were honored by a visit from Dr. Shoa-wen Ling, one of the world's foremost aquaculturists. Following a long and distinguished career in Asia, Dr. Ling is now adjunct professor in the School of Marine and Atmospheric Science at the University of Miami. Dr. Ling is best known as the first scientist to control the life cycle of *Macrobrachium rosenbergii*, the giant Malaysian freshwater prawn, for which he is affectionately acclaimed by his colleagues as the "father" of freshwater prawn culture. The development has great commercial as well as scientific importance because the freshwater prawn has the gourmet qualities of the finest marine shrimp but, once past the larval stage, can be cultured in fresh water. Dr. Ling's visit to Illinois was prompted in part by his interest in the use being made of the prawn at the Kinmundy field station of the INHS, the Sam A. Parr Fisheries Research Center. The work is being conducted in cooperation with the Prawn Aquaculture Program of the State of Hawaii, and the University of Hawaii.

In studies by D. H. Buck, R. J. Baur and associates at Kinmundy the prawns have been incorporated into a polyculture of Asian fishes whose specialized feeding habits are being exploited in the recycling of swine manure. The prawns provide an additional consumer for the uptake of nutrients, the control of eutrophication, the management of wastes, and an additional source of high quality protein. While production of this tropical Asian species will be limited by the short growing season in temperate Illinois, the results at Kinmundy have exceeded expectations. Following an escorted flight from Hawaii, 35,000 of the translucent, inch-long (0.09 gram) prawns were stocked on June 1, 1978, in four experimental ponds. At Kinmundy they received no food beyond that produced in the manure-enriched ponds. Following a period of 131 days, survivors had attained weights averaging 12.7 grams for all ponds, 17.6 grams for the most productive pond. In this best pond 20 percent of the prawns had attained lengths of 4 inches (9.6 cm) or larger as measured from the eye to the tip of the tail, which is market size in many areas where prawns are sold. It was a pleasure to learn, however, that even the smallest of the Kinmundy prawns were a gourmet's delight.

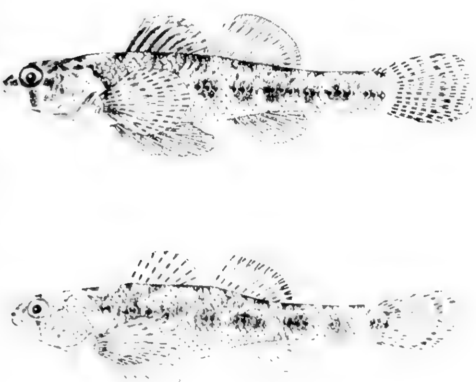
The total production of prawns was at rates of from 250 to 400 pounds per acre in addition to a production of more than one ton of fish per acre. Such high rates of production in temperate waters, with no supplemental feed, and against the competition of native crayfish, suggests the presence of compensating factors. The enrichment by the fresh manure and the abundance of partially-digested plankton (primarily algae) rained down on the prawns in the feces of a large population of filter-feeding fishes must create a milieu rich in organic detritus and both micro- and macro-organisms that is both tasty and nutritious to the omnivorous prawns.

The Cypress Darter

Of the 23 species of darters presently known to occur in Illinois, two are members of the subgenus *Microperca* (meaning small perch) and are among the smallest fishes in the United States. One of these, the cypress darter, *Etheostoma proeliare*, reaching a maximum adult size in Illinois of only 36 mm (1.5 inches) in length, was the subject of a life history study recently published by former Survey ichthyologist B. M. Burr and Survey ichthyologist L. M. Page. Copies of this publication, *Biological Notes No. 106,* are available upon request to this agency.

The cypress darter is found in leaf-laden and/or vegetated sluggish streams and margins of lakes and is distributed throughout the Coastal Plain province in the lower Mississippi River valley. One year of field and laboratory observations were made on a population in Max Creek, Johnson County, Illinois. In contrast to other darter species that have been the subjects of life history studies in Illinois, the cypress darter is shorter-lived (maximum of 18 months), much smaller in size, and has indented eggs that are in the shape of half-donuts rather than being spherical.

At one year of age the cypress darter spawns in vegetated or debris-laden pools. One to three eggs are laid at a time on leaves of aquatic plants, on algae, or on the sides of rocks. Laying eggs on leaves, undersides of rocks, etc. requires that the spawning pair assume vertical and inverted positions. The male mounts the female and expanded cuplike webs of skin on his pelvic fins allow him to grasp and hold onto the back of the female during spawning. Eggs are left unguarded by the parents and hatch in about nine days at 20°C. Growth is rapid during the first eight weeks. The cypress darter feeds principally on small crustaceans and immature aquatic insects.



Breeding male (upper) and breeding female (lower) of the cypress darter. (Drawings by Allice A. Prickett)

Life history studies contribute greatly to our knowledge of a species and its overall place in the environment and often reveal information useful in determining relationships to other species. The indented, half-donut shaped eggs and the pelvic-fin flaps found on breeding males are unusual, highly derived attributes of the cypress darter and indicate that the species is among the most highly specialized of all darters. Future studies at INHS will continue to concentrate on poorly known fishes for which information is much in demand by persons conducting environmental studies, students, and naturalists.

Dimorphic Protozoans

One of the many problems facing biologists involved in the classification of animals or plants is the occurrence of morphologically or biochemically different forms within a single species. Unless the dimorphic or polymorphic nature of the species is understood, the different forms are often described as several different species while these are, in fact, only variants of a single dimorphic or polymorphic species.

Such dimorphic species of microsporidia were the topic of a recent paper by Survey entomologists, J. V. Maddox and R. K. Sprenkel. Microsporidia are tiny Protozoan parasites primarily of insects. They are obligate parasites which infect the insect hosts either orally by ingestion of the resistant spores or transovarially via the eggs. Several hundred species of microsporidia representing 38 genera have been described from insects. Most of these microsporidia form only one type of spore depending on the genus to which they belong. However, some of the microsporidia studied by Maddox and Sprenkel produced two spore forms; one having characteristics of the

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genus *Nosema* and another having characteristics of the genus *Thelohania*. If the insect host is reared at 32°C or higher only *Nosema*-type spores are produced, but at lower temperatures both *Thelohania*-type and *Nosema*-type spores are produced. Both the *Nosema*-type and *Thelohania*-type forms were previously described as two separate species.

Among the methods used to prove that these forms were dimorphic forms of the same species, Maddox and Sprenkel used a density gradient technique to mechanically separate the two forms. When fed to susceptible hosts the *Thelohania*-type spores produced only *Nosema*-type at 32°C, while the *Nosema*-type spores produced both *Nosema*-type and *Thelohania*-type spores at lower temperatures. Maddox and Sprenkel also theorized that, since only *Nosema*-type forms are found at 32°C, if this were a mixture of two species, continuous passage through susceptible hosts at that temperature should eliminate the *Thelohania*-type form. However, the percentage of *Thelohania*-forms remained relatively constant during passage through eight hosts at 32.2°C.

Most of the *Thelohania* species described from lepidoptera occurred as mixed infections with *Nosema* sp. and many of these are probably single dimorphic species. These findings suggest that dimorphism may be common among the microsporidia infecting lepidoptera and extreme care should be exercised before mixed infections are described as two separate species.

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Weed-Eating Insects as Biological Control Agents

The purslane sawfly has been observed to cause considerable destruction to common purslane and was thought to be a possible biological control agent for this weed. Survey extension entomologist Roscoe Randell and University of Illinois Department of Horticulture researchers S. F. Gorske and H. J. Hopen conducted tests to determine whether the purslane sawfly feeds exclusively on common purslane and what effects some commonly used pesticides have on the purslane sawfly.

Common purslane is a weed that is not destroyed by normal cultivation practices. Once uprooted, purslane is capable of sending out adventitious roots and reestablishing itself.

Some purslane sawfly larvae mine out the contents of the leaf; another race feeds externally on the leaves.

One characteristic of an effective biological control agent is that it feeds only on the organism that it helps to control. If the weed plant is not present, the insect that helps to control it must not feed on other plants of economic importance.

Before a proper field management program can be established, it is necessary to know which pesticides are toxic to the control-agent insect under study. Several pesticides commonly used in Illinois vegetable fields were selected for tests on the purslane sawfly.

In the field studies, screen wire cages were placed around each weed to be tested and were set 5 centimeters deep into the soil to prevent the escape of the larvae. Larvae of the externally feeding and leaf mining types were collected, and three larvae of each type were placed in each cage. In each test, each experiment was replicated several times.

The testing of various plants as possible food sources of the purslane sawfly was also carried out in the greenhouse. Each plant to be tested was placed in a pot. Three larvae of each of the two feeding types were placed in each pot and a screen wire cage was placed over the pot.

Of the 17 plant species tested in the field, the purslane sawfly larvae fed only on common purslane.

Greenhouse studies of closely related plants showed a broader range of host plants. The purslane sawfly deposited eggs and fed on common purslane, and it developed normally on winter purslane. When seedlings of winter purslane were grown in the greenhouse, adult purslane sawfly females flew in through an open vent and deposited eggs on the leaves. The eggs and larvae developed normally, and the larvae fed only on the winter purslane.

Eight pesticides were selected for tests, including three insecticides, carbaryl, malathion, and *Bacillus thuringiensis;* three herbicides, DCPA, trifluralin, and nitrofen; and two fungicides, chlorothalonil and maneb. Externally feeding larvae were collected for this study, and 10 larvae and five purslane leaves were placed in a petri dish for each test. Each pesticide was applied to the leaves and larvae at one-tenth of the recommended rate for field use, at the recommended rate, and at 10 times the recommended rate. A plain water spray was used as a control test.

Carbaryl and malathion caused almost immediate and complete mortality of the sawfly larvae at all application rates. Of the sawfly larvae feeding on common purslane treated with *Bacillus thuringiensis,* 50 percent died from the recommended field rate, and the higher rate gave complete mortality. Direct application of the herbicides DCPA, trifluralin, and nitrofen at the recommended field rate or higher killed all of the larvae.

The fungicides chlorothalonil and maneb produced little or no mortality at or below the recommended application rate. The highest rate of application resulted in 100 percent and 95 percent mortality rates, respectively.

In the tests involving pesticides applied to the soil, purslane plants were planted singly in pots to which 10 larvae of the externally feeding type were added. A screen wire cage was placed over each pot. Three days after the sawfly larvae pupated, the herbicides DCPA and trifluralin were applied to the soil at the same three rates used in the foliar application tests. After the herbicides were applied, water was used to wash the herbicide into the soil.

The herbicides applied to the soil had no effect on the sawfly pupae, the cocoons preventing the herbicides from making contact with the pupae.

Other researchers have found that biological control of weeds is best accomplished by the use of insects on perennial weeds in range lands or other areas not under cultivation. Common purslane, an annual weed growing in intensively cultivated areas, does not fit that model. The Survey and University researchers concluded that the purslane sawfly has the potential of providing good control of purslane late in the growing season in cultivated areas and complete control earlier in the season in areas not under heavy cultivation or pesticide application. Control by the sawfly should be part of an integrated control program in which the major components are the use of selective herbicides and cultivation. Pesticides to control other pests might best be applied during the period when the sawflies are pupating.

Yellow-wood: A Forgotten Tree

Yellow-wood, *Cladrastis lutea,* a member of the bean family (Leguminosae), is native to the eastern United States and is one of our rarest trees. Survey botanist Ken Robertson recently published a review of the yellow-wood (single copies available on request). The species occurs in 12 states, primarily in the southern Appalachian highlands (Great Smokey Mountains, Cumberland Mountains, Cumberland Plateau) and the Ozark Plateau (Boston and Ouachita mountains) with a number of outlying populations, including Alexander County, Illinois; Brown County, Indiana; Brown County, Ohio; and Aiken County, South Carolina. Nowhere is the tree common. Wild yellow-woods usually are found on cliffs along river systems or in openings of moist coves in hardwood or hemlock forests. Because of its scarcity (there are fewer than 100 wild yellow-woods in Illinois), it is being considered for the official lists of threatened and endangered species of the United States and of Illinois.

Yellow-wood is one of the most beautiful flowering trees native to eastern North America. The tree is hardy throughout much of eastern North America, including most of Illinois, and is sometimes cultivated in parks, on campuses, in botanical gardens, and less often, in yards. In winter, the tree is attractive because of its gray, beech-like bark. In late spring, a yellow-wood tree in full flower is truly spectacular. In summer, the rounded crown, medium textured foliage, and short trunk make the yellow-wood a nice landscape tree. In autumn, the foliage turns a beautiful yellow.

However, yellow-wood should probably not be used for mass planting, but is best suited to the patient gardener, since the species takes 10 to 20 years to flower from seed. Individual trees flower heavily only every second or third year, and the species is difficult to purchase from commercial nurseries. A number of fine specimens of yellow-wood are in cultivation on the University of Illinois campus, in the Morton

Yellow-wood tree in summer. (Photo by K. R. Robertson)

Arboretum at Lisle, in the Missouri Botanical Garden in St. Louis, and in the Chicago Horticultural Society Botanical Garden.

The genus *Cladrastis* is of interest to botanists because of its distribution, with *C. lutea* in the eastern United States and four additional species in eastern Asia. This type of distribution indicates that the genus is an old one and once had a much broader distribution. As a result of the periods of glaciation, the genus was locally exterminated over much of its range, leaving relict populations only in eastern Asia and eastern North America. The present distribution of *C. lutea* reflects this history. Plant geographers theorize that the species occurred over much of North America during the Mesozoic but survived the Pleistocene glaciations only in areas that escaped inundation by glaciers or shallow seas. Following glaciation, the species expanded its range somewhat, particularly along certain major river systems, such as the Kentucky and White rivers. For some reason, however, the species has not been able to migrate into areas once covered by glaciers. Since the only Illinois population of yellow-wood occurs in an area that was not glaciated, it is possible that it represents a population that survived the glaciers.

Yellow-wood trees in cultivation are generally not troubled by diseases or insect pests. The branches are rather brittle and the crotch of the trunk is weak, making yellow-woods, particularly old ones, susceptible to wind and ice damage. Although the cultivated yellow-woods in Illinois are generally healthy, the wild trees are not, and many of them have dead or dying branches. The reason for this decline is not known, but may be due to diseases or insect pests, to the inability of the species to compete or persist under the present environmental conditions, or to past disturbances in the forest. Further studies are needed to ascertain the nature of this problem.

Trunk and main branches of yellow-wood tree in winter. (Photo by K. R. Robertson)

Trends in Cottontail Abundance

In November 1978 Survey biologists conducted roadside censuses of cottontails in the vicinity of Sibley, Ford County, and Neoga, Cumberland County, that further document the decline of cottontails in prime agricultural areas. These censuses followed the routes and procedures used by Survey biologist William R. Edwards for a similar census in November 1962.

In 1962 on the Sibley area, cottontails were counted on six evenings along 552 miles of rural roads, with 268 rabbits observed — 48.6 per 100 miles of driving. At

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Neoga in 1962 a total of 269 rabbits was seen on seven evenings along 545 miles of roads — 49.4 per 100 miles. During the 1978 census at Sibley, cottontails were counted on five nights along 450 miles of roadside, with only seven rabbits observed — 1.6 per 100 miles. This density represents a decline of almost 97 percent in the number of rabbits seen at Sibley between 1962 and 1978. At Neoga in 1978 cottontails were censused on six evenings over a total of 468 miles, with 29 rabbits sighted — 6.2 per 100 miles. This density represents a decline of about 87 percent in the number of cottontails observed at Neoga.

By comparison, counts of cottontails observed on summer roadside pheasant brood censuses at Sibley by Richard Warner and his predecessors at the Survey show 26.9 cottontails observed per 100 miles in 1962 compared with 2.2 rabbits observed in 1978 — a decline of 92 percent. Previously, Survey biologist D. Russel Vance (1976) reported a decline of cottontails from 5.1 flushed per 100 hectares censused on the Hunt Area in Jasper County in 1939 to 0.2 flushed in 1974 — a decline of 96 percent. Vance associated the decline of cottontails to drastic changes in habitat and land use at Hunt.

There can be little doubt that populations of cottontails in Illinois, particularly in prime agricultural areas, have been drastically reduced over the past 20–30 years.

Allerton Park, Piatt County, represents a situation where habitat has been relatively stable and minimally affected by changes in agriculture. Cottontails have been censused on the 4-H Area at Allerton Park in late October or early November for the past 23 years. Trapping in November 1978 indicated a population of 136 cottontails using the 4-H Area. Although the 1978 estimate was well below the estimate of 259 for 1977 and the peak estimate of 358 obtained in 1976, it was well above the estimate of 97 obtained by Edwards in 1962 and the mean estimate of 104 for the 4 years, 1962–1965. The 23-year mean estimate for the 4-H Area is 206 cottontails, with a range from 88 in 1965 to 358 in 1976.

The drastic long-term decline of cottontails in agricultural areas apparently is due in part to changes in land use and farming practices. In contrast, the cottontail population in the undisturbed habitat at Allerton Park appears to have remained relatively stable.

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FEBRUARY 1979, NO. 184

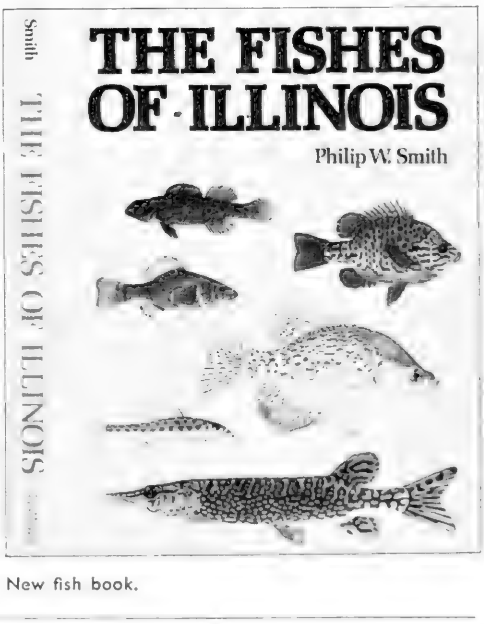
Fishes of Illinois

Among the responsibilities assigned by law to the Illinois Natural History Survey are "to conduct a natural history survey of the state" and "to publish, from time to time, reports covering the . . . zoology and botany of the state." The most recent of such reports is a book released in January entitled *The Fishes of Illinois* by Survey ichthyologist P. W. Smith. This report, which has superb color illustrations of 34 species, was published, and will be distributed solely, by the University of Illinois Press, 54 East Gregory Drive, Champaign, Illinois 61820. The post-publication price is \$20.00, but it is available to readers of the *Illinois Natural History Survey Reports* at a 20 percent discount, making the total cost \$16 plus a \$1 postage and handling charge and 5 percent sales tax for Illinois residents.

Smith and his associates spent 11 years collecting in various aquatic habitats throughout Illinois and in adjacent areas of bordering states. Some six years were spent in office research, writing the text, and preparing the illustrations. The paintings were done by Mrs. Alice Ann Prickett of the University's School of Life Sciences and usually depict males in breeding colors made from living but anaesthetized fishes.

The fish book treats the 199 species that occur, or did occur, in the state. A separate chapter for each family headed by the common and scientific names describes the family, its relationships, and economic importance. A key to genera follows with a paragraph briefly mentioning the content of each genus and how many of its species occur in Illinois. Each species account contains the common and scientific name, a synonymy of the names used in the Illinois literature, a diagnosis, a discussion of variation and subspecies, a summary of the ecology of the species, and a statement of its former and present distribution.

There are 185 black and white illustrations and 196 distribution maps. Each map indicates the distribution of the species prior to 1908 and, by a different type symbol, that at the present time. For the many species whose status has changed during the 75-year interval, the probable reasons for the changes are identified. The book also contains illustrated keys for identifying all Illinois species, a discussion of the history of ichthyological research in the state,



New fish book.

an extensive literature cited section, and a glossary. It has been anxiously awaited by biologists for more than 10 years.

Seventy Years Later

It is now more than 20 years since the second series of statewide censuses of bird populations was conducted in Illinois. The first censuses, conceived by Stephen A. Forbes in recognition of the need for quantitative data to understand ecological relationships, were started in 1905 by Alfred O. Gross with the help of fellow student Howard Ray, under Forbes' direction. The study was carried on intensively through 1909 and provided a population record probably unmatched anywhere in the world. Part of the data were published by Forbes and Gross between 1907 and 1923, and Gross left all of his original field notes at the Survey for further evaluation. Alfred Gross later became a renowned professor of biology at Bowdoin College. With his encouragement and advice and the Survey's support, Survey biologists Drs. Jean and Richard Graber carried out a similar series of censuses from 1956 through 1958.

In the 50 years between the censuses some interesting changes occurred, but overall the Illinois avifauna had remained remarkably intact. It was fortuitous that the second series of censuses came when they did, on the brink of enormously rapid change in the habitats of Illinois. Included among the changes were vastly increased use of insecticides and herbicides and great changes in habitat availability. Illinois has changed more in the past 20 years than it did in the previous 50 years. Although the Grabers have been censusing forest areas the past 5 years using the Forbes-Gross technique, in 1978 they started work on other habitats, the ultimate goal being to determine what is happening to bird populations in these times of such rapid change.

Even though the same technique can be used, one important change has been forced upon the census takers. The earlier censuses covered the various habitats in a random sequence as they were encountered on cross-country transects. Ample samples of most of the habitats were eventually acquired in this way, including even the rarer habitats such as marsh and ungrazed grassland. Now, random transects would be unlikely to encounter the rarer habitats and the investigators must seek out such habitats in the few places they still exist. That change complicates the interpretation of the data, because there is no way to determine whether the surviving tracts of habitat differ in important ways from the habitat in general. The investigators have no choice in the matter. If any data are collected on certain habitats, such as marsh, the investigators must census what is left.

Yellowheaded blackbird on cattails in a northern Illinois marsh (photo by Jean Graber).

Herbert H. Ross

Dr. Herbert H. Ross, former principal scientist, assistant chief, and head of the Section of Faunistics and Insect Identification, died in Athens, Georgia in November, 1978, at the age of 70. Dr. Ross retired from the Survey in 1969 after more than 40 years of service. He took a teaching position at the University of Georgia from which he retired in 1975.

One of the most respected scientists in North America, Dr. Ross published 220

Herbert Holdsworth Ross.

scientific works, including 7 books and chapters in 6 other books. He was active in several scientific organizations and served as president of the Entomological Society of America (1954–55), the Society for the Study of Evolution (1966–67), and the Society of Systematic Zoology (1973–74).

A memorial fund has been established in Dr. Ross's name to support systematic research in entomology at the University of Illinois and the Illinois Natural History Survey. Readers who knew Herb Ross and would like to provide a lasting tribute to his memory can make a contribution to this fund. Checks should be made payable to the University of Illinois and marked for the Herbert H. Ross Memorial Fund. Please send contributions to the University of Illinois Foundation, 224 Illini Union, Urbana, Illinois 61801.

Crop Pests of 1978

Extension entomologists in the University of Illinois and the Natural History Survey and other extension specialists held the thirty-first annual Custom Spray Operators Training School at the University on January 9, 10, and 11. Entomologists Kevin Black and Gary Braness presented information on the 1978 insect situation and insecticide usage, and also on the outlook for insect conditions in 1979. Much of the information regarding the ranking of the insects and estimation of insecticide usage in Illinois was compiled from reports submitted by county extension advisers.

Of the common insect pests of field crops in the state only corn rootworms declined significantly. This decline was caused by late planting of corn, a factor which helped promote black cutworm problems. Black cutworms were ranked by county extension advisers as being second only to European corn borers in terms of damage, amount of pesticides applied, and numbers of calls for assistance or information which were received in the county offices. Grasshoppers were ranked by advisers as the third worst insect pest in Illinois. Grasshopper populations have been steadily increasing over the past few years and many fields of both corn and soybeans were damaged in 1978.

Other agricultural insects which were considered especially bad this past year included corn earworms, bean leaf beetles, stored grain insects, rootworm beetles, and fall armyworms. Alfalfa weevil problems were reported from occasional fields of alfalfa in northern Illinois, an unusual situation since damage from this insect normally occurs only as far north as Peoria. Another unusual situation was a corn borer infestation in a field of first-trifoliate-stage soybeans in Jasper County.

Prediction of insect problems for 1979 is difficult at best. Black cutworm infestations are highly dependent upon spring weather, weed conditions, planting date and other factors. Likewise, European corn borer infestations are highly weather dependent. The amount and type of fall and spring tillage, as well as planting date, greatly affect resulting populations of borers. Because of the tremendously high fall generation of corn borer populations in Illinois in 1978, conditions for 1979 should be regarded as threatening. Grasshoppers are also likely to be a problem again in 1979 if

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weather during the early summer egg hatch is relatively dry. Cool wet weather during the egg hatch could greatly reduce grasshopper damage potential.

Rootworm populations, which were greatly reduced between 1977 and 1978, are likely to remain relatively stable. The number of rootworm beetles laying eggs in 1978 suggests no large increase in populations for 1979. Populations of other insects such as alfalfa weevils, corn earworms, fall armyworms, etc. are nearly impossible to predict.

Growers can greatly improve their chances of getting maximum yields if they will frequently inspect their crops for developing insect problems. Should problems or questions arise, the entomologists of the University Extension Service and Natural History Survey are always willing to help.

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Alfalfa Weevil Hunt

Attempts to control the alfalfa weevil with fall insecticide applications have not always been successful. Alfalfa weevils go into aestivation, a torpid or dormant state induced by the heat and dryness of summer. Economic entomologists R. J. Barney, S. J. Roberts, R. D. Pausch, and E. J. Armbrust recognized the need for information about when alfalfa weevil aestivation ends, when the weevils return to alfalfa fields, and the timing of their dispersal and subsequent egg laying throughout the fields. It is believed that some alfalfa weevils aestivate in woods bordering alfalfa fields. Therefore, the entomologists conducted a study in Washington County in southern Illinois, where many wooded field borders serve as aestivation sites for alfalfa weevils.

The study site was a 24-acre alfalfa field bounded on the north by soybeans, on the south by corn, on the west by a road and corn, and on the east by woods. Four alfalfa weevil sampling methods were used: emergence traps, flight traps, sweeping with nets, and collecting egg samples.

Each emergence trap covered an area of 1 square foot, and they were designed so that any insect or other active organism emerging beneath the trap was collected in a jar. The six emergence traps were placed in the woods along the border of the alfalfa field. Each trap was checked periodically, and any alfalfa weevils were removed and recorded.

Each flight trap was a rectangular box supported by a metal pipe. A sheet of clear Plexiglas was positioned 30 degrees forward of vertical above the box to deflect any flying organisms into ethylene glycol contained in the box. Four flight traps were placed in the alfalfa field 40 feet from the woods and facing the woods. During periodic checks any alfalfa weevils were removed with an aquarium dip net and recorded.

A standard 15-inch-diameter sweep net was swung across the tops of alfalfa plants to locate weevils within the field. Five sets of 50 sweeps were made at five evenly spaced intervals across the field, the first set near the wooded east border of the field and the fifth set near the west side. The

The termination of alfalfa weevil aestivation and the pattern of reentry into a field have been studied by Survey entomologists. (Photo by former Survey photographer W. D. Zehr)

number of adult alfalfa weevils was recorded for each set of sweeps on every sampling date.

Each egg sample consisted of a one-quarter square foot area of alfalfa removed with a knife and placed in a plastic bag. The alfalfa was ground in a blender and washed through a series of screens to reveal the alfalfa weevil eggs. Five egg samples were collected at each of the five locations where net sweeps were made. Egg samples were collected until the average daily temperature was below the threshold of development for the alfalfa weevil (48° F.).

The entomologists found that not all alfalfa weevils ended their aestivation at the same time. The emergence traps revealed two peaks of activity. A small group of weevils appeared in the traps in early September, while the majority were found in mid- to late October. More than 300 acres of alfalfa were in the area surrounding the study field, and some growers were forced to cut alfalfa before the optimum time. Other researchers have suggested that cutting alfalfa earlier than usual in the spring, which results in much higher ground temperatures than would otherwise be encountered, may initiate alfalfa weevil migration from the alfalfa to aestivation sites. This early initiation of aestivation by a minority of weevils may result in an early termination of aestivation by these same weevils, perhaps explaining the emergence in early September.

The flight trap catches showed that alfalfa weevils moved into the field about a week after emerging from their aestivation sites. However, the flight traps caught only a small number of weevils, possibly indicating that more flight traps should have been used or that they were placed at an incorrect height or distance from the field border. Another explanation may be that weevils reentered the field by short flights or simply by walking, which would not be detected by the flight traps.

The sweep-net data revealed a large adult weevil population in the field 3 weeks after their emergence at aestivation sites. Once the weevils end their aestivation and begin to reenter the alfalfa field, a feeding period at the edge of the field may be necessary before they disperse throughout the field. Sweeping the field at five locations showed that field reentry was a gradual process, beginning at the wooded field border. In late October more than 50 percent of the alfalfa weevils were located near the wooded border. By mid-November the weevil population was well dispersed throughout the field.

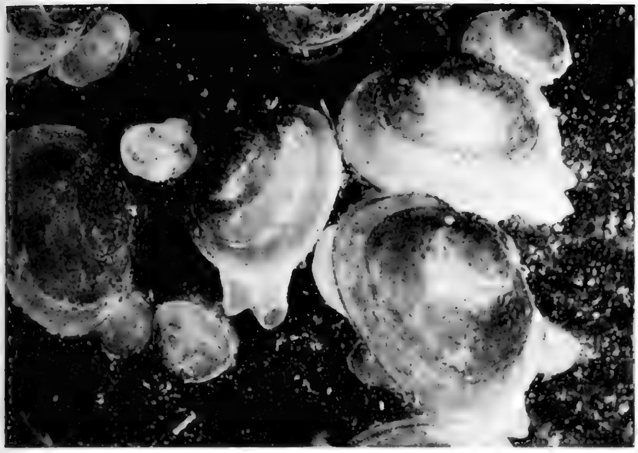
The data from the egg samples demonstrated the same gradual field dispersal. On 1 November almost 60 percent of the weevil eggs were found along the wooded edge of the field. By mid-November egg density was uniform throughout the field.

The termination of alfalfa weevil aestivation and the pattern of reentry into a field may be different for various areas because of the availability of aestivation sites, the timing of spring alfalfa cutting, and climatic conditions. Data will have to be gathered for local areas to predict accurately the best time for fall application of insecticides as a part of an integrated pest management program.

Fingernail Clam Bioassays

Before 1955 fingernail clams were abundant in the Illinois River. In that year, for some reason still unknown, fingernail clams died out in the Illinois, and they have never recolonized the areas where they formerly lived. These clams are used for food by diving ducks, such as the canvasback and lesser scaup, and by some bottom-feeding fish. The use of the river by diving ducks and the condition of bottom-feeding fish have declined as a result of the fingernail clam die-off. The demise of the fingernail clam in the Illinois River contributed to the decline of the commercial fishery there, and the remaining commercial fisheries on the Mississippi River are dependent on fishes that feed on fingernail clams.

Research has been in progress for some time at the Survey's Illinois River Laboratory, using an apparatus which exposes fingernail clams collected from the Mississippi River to raw Illinois River water treated to remove suspected toxicants. Survey aquatic biologists Richard Sparks and Michael Sandusky expect to learn, by a



Fingernail clams, formerly abundant in the Illinois River, died out there in 1955 and have never returned. They are an important food source for diving ducks and some fish. (From a color transparency by Dr. R. E. Sparks)

process of elimination, which factors in Illinois River water prevent fingernail clams from recolonizing the river. The results of this research could also be used to prevent the die-off of fingernail clams in the Mississippi.

Testing has been impeded because of equipment failures, contamination of Illinois River water by metals leaching from the intake system, and the failure of some batches of fingernail clams to grow well or survive under laboratory conditions. However, steps have been taken to solve these problems, and research progress is being made.

Culture tests have shown that after 4 weeks the survival of fingernail clams in petri dishes containing silt is much better than it is in petri dishes without silt. The growth rate of clams is also slightly better in silt. Therefore, fingernail clams will be maintained in silt during subsequent bioassays.

Some of the mortality in fingernail clam cultures maintained in the laboratory is attributable to leeches that prey on the clams. These leeches are introduced in the sediment which accompanies the clams when they are collected from the Mississippi River. Consequently, the clams may have to be handpicked from the sediment before they are placed in culture tanks, and the sediment used as a substrate in the tanks may have to be sterilized by heating.

These experiments may eventually unlock the secret of why fingernail clams died out in the Illinois River, and they may also point the way to cleaning up the water so that fingernail clam populations can be reestablished in the Illinois.

Sandhill Crane Migration

In cooperation with the University of Wisconsin and the U.S. Fish and Wildlife Service, Survey wildlife biologists William W. Cochran and Arlo Raim studied the fall migration of sandhill cranes from the interlake region north of Winnepeg, Manitoba, where these birds breed, to their wintering grounds on the Texas coast. Raim devised two radio transmitter designs for mounting on the leg band normally used by wildlife researchers for marking this species. One of the designs was conventional, being powered by batteries for a predicted life of 1 year. The other used photocells to provide an indefinite period of operation. A total of 12 transmitters was constructed. The Canadian Wildlife Service placed the transmitters on nestlings in late July.

Personnel from the University of Wisconsin and the Canadian Wildlife Service monitored the birds as they dispersed from their breeding area to southern Manitoba and North Dakota, where they spent the last part of August and all of September. Cochran went to North Dakota in early October, prior to the migration of the sandhill cranes, to instruct personnel from the University of Wisconsin in the techniques used for following migrants. One

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bird, in a flock of about 500, was followed to a wintering area for the species southwest of Houston, Texas.

These birds turned out to be easy to follow because they travel slowly and make their migratory flights during the same period each day (from 1100 to 1730 hours).

Cochran's interest was in the possibility for observing the homing phase of this migration during which the birds were expected to alter their generally southward course to seek out their specific wintering areas. It was expected that a rather abrupt change would be noted about the time the birds reached the latitude of their goal.

The cranes' flight was almost due south for the first 800 miles (this took 4 days) after which the flight distance covered per day was reduced to about 80 miles and the flight direction became rather unpredictable. Flight was generally to the southeast, south, or southwest, seemingly dependent upon wind direction. However, during the last half hour to hour of flight each day, the direction shifted to almost straight east or west. During this period, the flock size (the number of birds with the radio-equipped bird) was reduced gradually to about 200 birds and, finally, to about 70 birds.

These observations suggest that experienced members of the flock search out familiar landmarks during the latter portion of the migration, with flock breakup due to differing goals. If this is the case, this species is a poor one for definitive studies of orientation and navigation mechanisms.

The principal objectives of the study were to evaluate habitat use during migration and to field test the technique and train personnel for a follow-up study of the endangered whooping crane in 1979-1980. The study will be continued with the spring migration of the sandhill cranes already radio tagged (and later, the whooping cranes) by researchers from the University of Wisconsin.

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APRIL 1979 NO. 18[illegible]

Bee Systematics — Melandrena

The genus of bees known as *Andrena* includes nearly 500 species in North America and as many or more in the Old World. Many of these bees are important pollinators of fruit crops such as strawberries, blueberries, apples, pears, plums, cherries, and native plants such as sunflowers. Survey entomologist W. E. LaBerge and several associates have been studying the systematics of the North American species of *Andrena* for several years. These studies are being supported in part by funds from the National Science Foundation, and they are a prelude to a faunal study of the bees of Illinois.

Systematic studies have several purposes among which are: to make known the different kinds of organisms, to make known their valid scientific name, to name forms that have not been named, to provide illustrations and keys so that other scientists can identify the species, to describe their variation, geographical distribution and habits when known. It is frequently of practical importance to be able to accurately identify species. For instance, if a scientist were studying pollination of apple trees in northern Illinois, he would have to be able to recognize *Andrena thaspii,* a bee important in apple pollination. However, there are three or four other species of *Andrena* which may be active in northern Illinois at the same time as *Andrena thaspii* and which are very similar in appearance to *thaspii.* These other species do not visit apple tree blooms or do so only infrequently. Without a carefully constructed key, illustrations, and descriptions, no one would be able to make the critical distinctions between these species of *Andrena,* and the scientist may spend considerable effort studying the wrong species. Also, the valid scientific name of a species is the indispensable key to all previously published information regarding that species.

The ninth part of the revision of the

Andrena (Melandrena) carlini resting on flowers of toothwort (Photo by Joseph Laury Luth).

bees of the genus *Andrena,* describing a group of species known collectively as the subgenus *Melandrena,* was recently completed by Survey entomologists John A. Bouseman and Wallace E. LaBerge. This study was based upon over 12,000 specimens which segregate into 22 species. The species of *Melandrena* are spring or early summer bees, and several are important pollinators of fruit trees and berries. One common fruit tree visitor, previously without a name, was named *Andrena illini* by Bouseman and LaBerge because it is common throughout the state of Illinois.

Coal Conversion Wastes

With the shrinking of the world's petroleum resources, energy planners are taking a fresh look at the nation's energy sources, especially coal which represents a large percentage of our energy resources. Coal gasification and liquefaction are two methods by which coal can be converted to synthetic gaseous and liquid fuels. However, the conversion of coal is not without environmental impact. The amount of solid waste produced by a single coal gasification plant over 20 years is estimated to occupy 1,250 acres to a depth of 10 feet. The disposal of these huge amounts of waste is unprecedented and successful commercial production of these fuels will partially depend on the "safe" disposal of their wastes. Survey aquatic biologists John J. Suloway and William F. Childers in conjunction with members of the Illinois State Geological Survey have been investigating the impact of leachates generated from coal conversion wastes on the aquatic environment in a study funded by the federal Environmental Protection Agency.

The four phases of the project included examining the mineralogy of the coal solid wastes, the solubility of chemical constituents of the waste, the attenuation of leachates by the soil, and the toxicity of leachates generated from coal conversion wastes to aquatic organisms. Suloway and Childers were primarily involved with the toxicity testing. The primary objectives of the toxicity tests were to determine: a) if coal conversion waste leachates were acutely toxic to young fathead minnows, b) how much dilution was necessary to eliminate mortality caused by a leachate during a 96-hour test and c) which water soluble chemical constituents were responsible for the toxicity.

Ninety-six hour static bioassays of the leachates were conducted with one to six-day-old minnows, *Pimephales promelas.* Small, young fish were used since it was occasionally difficult to obtain large quantities of solid waste from which leachates could be generated. For example, Illinois coal had to be shipped overseas to be processed at a power plant in Scotland in order to obtain coal gasification ashes. The bioassays were conducted under controlled conditions in an environmental chamber where the temperature was maintained at 21 ($\pm$ 1) C and there was a constant photoperiod. Approximately 14,000 minnows were utilized in bioassays of 88 leachates.

Approximately half of the natural leachates were acutely toxic to young fathead minnows under laboratory conditions. Several acidified leachates were very toxic and required large amounts of dilution ($>$ 1:100) to ensure survival during a 96-hour bioassay. The extent of a leachate's toxicity and the amount of dilution necessary to ensure survival during a 96-hour bioassay were largely a function of acidity and total ion concentration. Some of the leachates contained potentially hazardous concentrations of aluminum, chromium, copper, magnesium, nickel and zinc. Suloway and Childers plan to continue this research in order to study long-term effects of these leachates and the effects of these leachates on other aquatic organisms.

Illinois River Timber

Several hundred acres of bottomland forest exist in the floodplain of the Illinois River on islands and along the shorelines of the river and its associated backwater lakes. The majority of the bottomland timber occurs along the lower two-thirds of the river from the Great Bend, near Hennepin, to Grafton. One aspect of the Lake Michigan Diversion Project was to assess the effects of increased water levels on the

Bottomland forest, chiefly silver maple, near Rice Lake, Illinois (Photo by Steven P. Havera).

floral and faunal species comprising the bottomland forest community of the Illinois River.

During the fall of 1978, wildlife biologist Stephen P. Havera and associates Donald Steffeck, Fred Paveglio, and Kathleen Archer sampled 15 tracts of bottomland timber between Hennepin and Grafton, and gathered such data as species composition, basal area, density, tree size (DBH), and the monetary lumber value of the timber.

By combining these field inventories of the bottomland tree species with their tolerances to various water conditions as reported in the literature, the possible effects of increased water levels on the timber of the Illinois River can be assessed.

A total of 18 tree species were tallied in the timber cruises. Silver maple, cottonwood, and species of ash were found in all 15 tracts of timber sampled; elm species in 14 of the tracts; willow, hackberry, pecan, and sycamore in about half of the study areas. Box elder, river birch, honey locust, red mulberry, basswood, hawthorn, pin oak, persimmon, sugarberry, and swamp privet were found in 25 percent or less of the tracts.

The basal area of the bottomland timber stands sampled varied from 95 to 173 sq. ft. per acre. In all of the 15 stands, silver maple accounted for the majority of the basal area, with an average of 64 percent of the total basal area for all 15 areas. The density of bottomland trees varied from 95 to 304 trees per acre among the study areas. The area with the smallest density of trees (95 per acre) was near Meredosia. This tract also had the largest trees inventoried with an average diameter at breast height (DBH) of 25.8 inches. The remaining timber stands had average DBH values between 12.2 and 17.9 inches.

The number of board feet was calculated from the number of sawlogs tallied for each tree species on the study areas. Utilizing the most recent Illinois timber prices, an estimated value of the lumber could be derived. The value for sawtimber in bottomland stands sampled varied between $254 and $595 per acre. These estimates should be considered as maximum amounts. The stand with the highest sawlog value

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per acre was in Sanganois State Park at the confluence of the Sangamon and Illinois rivers.

Perhaps the most impressive timber stand sampled was at Godar's Swamp near Kampsville. Here large pecan trees accounted for 30 percent of the basal area. Some of these pecan trees had DBH's of 36 inches. A good population of large cottonwood trees and a fair number of pin oaks were also present.

Timber from four of the 15 tracts sampled had been harvested within the last 5 years. Because of selective timber cutting and agricultural encroachment upon bottomland areas, pecan and pin oak stands once prevalent along the southern reach of the Illinois River are being transformed to stands dominated by silver maple.

Insect/Plant Relationships

The practical implications of how insects select plants upon which to feed and how plants evolve to avoid being eaten justify research efforts in this field. Recently, entomologist Marcos Kogan published a paper summarizing information on insect/plant chemical interactions in which he suggests several basic models in the host-selection processes followed by various insects.

About half of all known species of insects are more or less dependent on plant hosts. Generalized feeding, or polyphagy, seems to be a primitive stage in insect/plant interactions and oligophagy (few plant hosts) the rule among plant-eating insects. The information available on host-selection processes is based on few insect/plant relationships. Only 18 plant families out of about 320 existing families of higher plants have had representative species investigated in this way. As these studies expand to include other plants and insects, additional models will be recognized.

These insect/plant associations involve sensorial, physiological, and ecological processes mediated by many factors. There is little doubt, however, that plant allelochemics are the key factor in the establishment of the associations. The identification of the chemical bases of host-plant selection by insects and of host-plant resistance to insects can greatly improve the efficiency of programs for breeding resistant varieties of plants. It can also open new avenues for the manipulation of insect's behavior for use in pest management programs.

Although the practical aspects of insect/plant asociation studies are obvious, the scientific knowledge to be gained on the interdependence of organisms and their harmonic coevolution makes such studies especially exciting and attractive.

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The Persistence of Benomyl On Walnut Fruit

The severity of anthracnose leaf spot on black walnut, a major disease of this tree species, causing premature defoliation, reduced growth, malformed nut meats, and possible tree death, has recently been found to be reduced by applications of the fungicide benomyl. Successful treatments have been made through leaf spray and soil injection methods. The ability of this fungicide to control many other pathogens has been well documented since its introduction in 1967. Benomyl is a systemic fungicide that moves through a tree's vascular system from one part to others.

Researchers have shown that MBC, the stable product formed when benomyl is suspended in a water-based medium, can have long-lasting effects on disease development for up to several years after soil application. Foliar applications have also resulted in MBC residue accumulation in the xylem tissue, but its movement to other plant parts is slow and for the most part restricted to areas about the point of application.

In both leaf spray and soil treatments, the prime site for MBC accumulation is in the foliage. Scientists elsewhere applied benomyl sprays to the external surfaces of oranges and detected residues in the juice for up to 84 days after treatment. The persistence of benomyl on exterior surfaces, acting as a reservoir for its subsequent systemic movement into the plant over long periods of time, is an obvious asset to its use in curbing disease.

Because of the systemic nature of benomyl and the uncertainty of its movement, particularly into floral parts and fruits, plant pathologists Dan Neely and Steven Cline decided to determine the persistence of benomyl on and in walnut fruit when applied as foliar sprays, as trunk infusions, and by soil injection.

The ability of benomyl to persist on nut hulls was found to be a function of its con-

Black walnut trees are now a plantation crop. The tree in the center has been extensively defoliated by anthracnose.

centration. The spray concentration normally used on walnut plantations lasted about 5 weeks, when more than one-half of the inhibitory effectiveness was lost, as measured by bioassays. Spray treatments two and four times the normal concentration lasted longer, but all foliar spray treatments were 97–98 percent ineffective at inhibiting the test fungus 2½ months after treatment.

Soil and trunk injection results suggested the possible uptake and translocation of benomyl (MBC) to nut hulls when some of the bioassays displayed sensitivity after 48 days. These data, however, do not appear significant and require additional testing.

Correlations between benomyl residue persistence on nut hulls and amounts of precipitation, both in the field and under simulated rainfall in the laboratory, indicated an interaction. At test sites at Urbana, Carbondale, and Fisher, rainfall of 5–7 inches accompanied a decrease in benomyl effectiveness of 80–90 percent. At the Martinsville test site, however, more than 5 inches of precipitation fell, but no marked change in bioassay results appeared. Laboratory rain bioassay experiments demonstrated the ability of benomyl to remain effective after 24 inches of precipitation. These results indicate that other factors may be involved in the ability of benomyl to persist on nut hulls.

Nut meat tests resulted in a lack of detectable benomyl residue. A more sensitive testing method is now being sought for the detection of smaller fungicide amounts than can be detected through bioassays.

Abundance and Migration of Woodcocks

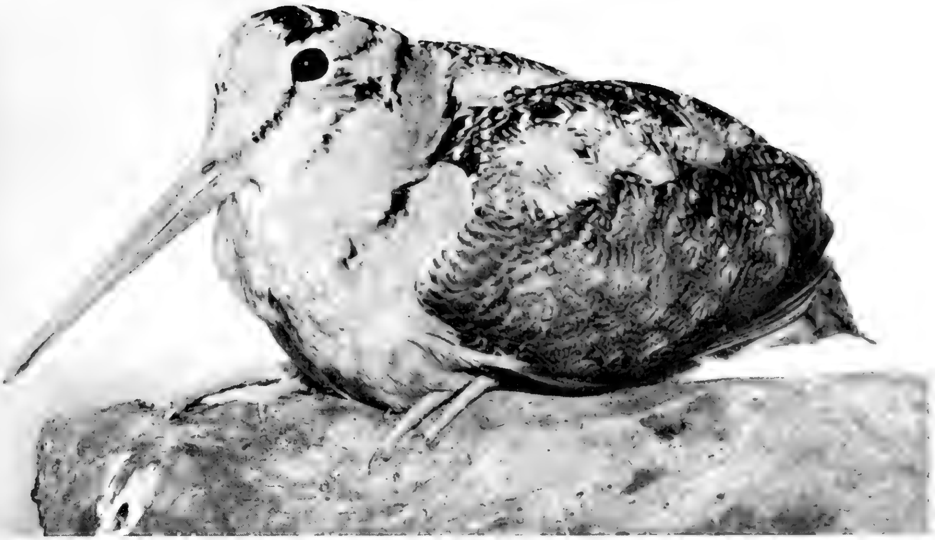
The date of arrival of woodcocks in central Illinois in 1978 is not known. However, on March 15 Survey Biologist Charles M. Nixon observed a male exhibiting what is believed to be territory-establishing behavior, called "displaying," on snow-covered ground along the Vermilion River south of Danville.

Wildlife Specialist William R. Edwards and his associates are studying the woodcock to learn more about how to manage it as a living natural resource. They estimated that 38 woodcock territories were active through May on the Forest Glen Nature Preserve, also along the Vermilion River, and on lands immediately adjoining the preserve. Peak numbers of woodcocks were observed during June at Forest Glen, but woodcock sightings declined in July and August. Woodcocks were observed almost every evening, but in much reduced numbers, in late August, September, October, and early November. Where 15–20 birds might be seen on an evening in June, only 2–4 might be seen in late summer. Single birds were seen on November 17 and 21, the last to be observed at Forest Glen in 1978.

On November 11, the opening day of the 1978 upland game hunting season in Illinois, hunters reported flushing unusually large numbers of woodcocks over much of central Illinois. Examination of weather data indicated the southeasterly passage of a frontal system through Wisconsin on November 5 and through Illinois on November 6. Rainfall was quite general in Illinois on November 6 behind the front. Following the passage of the front in Wisconsin, the barometer was relatively high, temperatures were low, and winds were out of the north and northwest — conditions basically favorable to woodcock migration. The investigators concluded that probably there was a major woodcock migration out of Wisconsin on the evening of November 6 and that migration ended when the birds caught up to the rain in central Illinois. As a result, large numbers of woodcocks were present in Illinois on November 7.

On the assumption that southward migrations proceed on the basis of high pressure systems and southerly or southeasterly movements of air following the passage of frontal systems, the next weather conditions favorable for a major migration of woodcocks out of Illinois took place during the period of November 19–21. No woodcocks were observed at Forest Glen after November 21.

Weather in Illinois in January and February 1979 was much colder than normal, and snowfall was much above



Survey wildlife specialists are studying the abundance and migration of the woodcock in Illinois. The bird shown here was injured when it flew against a large picture window.

normal. The passage of the first major warm front of 1979 occurred on March 2. Temperatures in the 50's occurred on March 3–4. Rainfall was general in Illinois on March 4 with winds out of the south. On March 4 Nixon again observed a woodcock near the Vermilion River, and Ms. Marilyn Campbell, naturalist for the Forest Glen area, reported a woodcock that was seen on March 4 in nearby Westville. On the evening of March 5 the Forest Glen area was censused for the first time in 1979, and woodcocks were found displaying on or near all territorial sites visited that had been occupied in 1978 and in several locations that were not regularly used in 1978.

Here again was a pattern of woodcock migration associated with the passage of a frontal system followed by a wind favorable to the direction of migration and apparently terminating with rainfall. The northward migration was associated with a warm front, whereas the southward migrations of November 1978 were associated with cold fronts. In their continuing investigations the researchers expect to learn more about woodcock abundance and migration patterns.

Even the Bugs Have Bugs

The alfalfa ecosystem, unlike many other field crops, represents a relatively long lasting, well-established perennial system. Thus, it serves as a natural nursery for many predators, parasites, and pest species which may eventually migrate to neighboring annual crop systems, such as soybeans. Many pests of the order Lepidoptera, whose larval forms are caterpillars, are commonly found on soybeans and alfalfa, and some are serious pests of both crops. To control insect pests of field crops through integrated pest management programs, it is necessary to know which parasite species occur naturally in pest species at each stage of their lives. Entomologists Stephen Roberts, W. K. Mellors, and Edward Armbrust decided to research the relationships of parasites and lepidopterous larvae in soybeans and alfalfa to understand more fully the importance of parasites as biological control agents.

In the first growing season of this study, 10 soybean and 5 alfalfa fields were sampled, and in the next season, 14 soybean and 8 alfalfa fields. Larvae were collected with a standard 15-inch sweep net; the entomologists made 200 sweeps per field

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at about 1-week intervals. The larvae that were collected were reared on suitable artificial diets or on fresh alfalfa leaves. The rearing continued until adult Lepidoptera emerged, parasites emerged, or the larvae died from unknown causes. The percentage of parasitism was calculated for pest species.

Ten species of lepidopterous larvae were collected in Champaign County in the two growing seasons. These species, with the percentages (in parentheses) that were attacked by parasites in alfalfa and soybeans, were the green cloverworm, *Plathypena scabra* (43.3 and 32.4); the celery looper, *Anagrapha falcifera* (38.2 and 37.9); *Autographa precationis* (no common name) (the population was too small to determine percentages of parasitism); the variegated cutworm, *Peridroma saucia* (34.1 and 46.7); the alfalfa caterpillar, *Colias eurytheme*, and the clouded sulphur, *Colias philodice* (these two species were not separated because of the possibility that they may hybridize and because it is difficult to identify species of larvae in the genus *Colias*) (47.0 and 47.0); the forage looper, *Caenurgina erechtea* (9.7, and the population in soybeans was too small to determine the percentage of parasitism); the yellowstriped armyworm, *Spodoptera ornithogalli* (36.0 and 40.6); the armyworm, *Pseudaletia unipuncta* (21.4 and 52.8); and the yellow woollybear, *Diacrisia virginica* (24.0, and the population in soybeans was too small to determine the percentage of parasitism).

All of these species of lepidopterous larvae were collected in both alfalfa and soybeans in both growing seasons, except for *A. precationis*, which was not collected in soybeans in the second season. A total of 27 parasites, including two hyperparasites that attacked some of the parasites, were found in the host species. All parasites and hyperparasites were identified as to genus, and all but two were identified to species.

Possibly as a result of the influence of pathogens and parasites or both in combination with other factors, the seasonal averages of most of the lepidopterous larvae collected were less than one per 100 sweeps of the collecting net for both years in both crops. Only the green cloverworm and the *Colias* species had averages of more than one per 100 sweeps in one or both crops. Undoubtedly the parasites played a part in controlling these pest populations.

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Squirrel Nests

Both gray and fox squirrels use tree holes for shelter or construct nests of leaves and twigs in trees. A nest in a tree cavity should be warmer and more protected than one made of leaves or twigs and, likewise, nest boxes ought to be comparable to tree holes. If this hypothesis is correct, squirrels wintering in nest boxes should be in relatively better physical condition than those wintering in leaf nests.

Survey wildlife biologists C. M. Nixon and L. Hansen compared the percentage of carcass fat for male fox squirrels collected from nest boxes with male fox squirrels from leaf nests in late February 1978 in Vermilion County, Illinois. These biologists also evaluated the use of nest boxes by fox squirrels by collecting data on the physical environment surrounding each nest box. Some 27 variables such as height of box from ground, tree species, number of escape trees, and direction of box entrance were used in an analysis of their effect on the use or non-use of nest boxes.

Nixon and Hansen found that male fox squirrels from nest boxes did not have significantly more fat than those from leaf nests. Only two physical factors were found to be important to the use of nest boxes by fox squirrels. There was a positive relationship between box height above ground and box use and a negative relationship between number of existing tree holes in the nest box tree and squirrel use of that box. Thus, to maximize use of a nest box by fox squirrels, nest boxes should be placed as high in a tree as possible and should not be put in a tree with an existing cavity.

Another method of enhancing squirrel populations is by retaining some large trees with cavities when timber is harvested.

Gray squirrel (Photo by Larry Farlow, former Survey photographer).

Wildlife biologists Nixon and Hansen counted all trees with a diameter at breast height (dbh) of 5 inches or greater on 63.5 acres of forest to determine which species of trees produced most tree cavities and in what size of tree were these cavities most likely to be found. Three species of trees — sugar maple, basswood, and beech — contained significantly more cavities than expected, and white and black oaks and hickories contained fewer cavities than expected from their abundance in the forest. A majority of trees with cavities were larger than 12 inches dbh. The retention of 2 to 4 maples, basswood or beech trees per acre during selective harvesting of timber in a hardwood forest should provide squirrels and other cavity nesting wildlife with sufficient nesting sites with little loss of valuable timber.

Collections and Collectors

An extremely valuable resource at the Natural History Survey is the systematic collections of plants and animals. Many scientists are well aware of them and make almost constant use of them, but the general public may not have given much thought to the value of collections that date back a century or more ago. They have been used primarily for research and reference (direct comparison for identification purposes) rather than for public display, but today with the intense interest in baseline data for environmental impact statements they are proving to be a goldmine of information on environments of the past. They provide a picture of what Illinois habitats were like at almost any given period during the past 100 years, what organisms were present, and even something about the relative abundance of these plants and animals.

While serious studies of plants in the State predate those of animals, the material collected and reported upon was not deposited at the Survey. The earliest specimen in any of the collections is a remarkably well-preserved sturgeon collected in the Ural River of Russia by a Dr. Lewzerow in 1862 and apparently sent to Survey scientists in a specimen exchange. A few fish and insect collections made in Illinois during the 1870's are extant, and many specimens of fishes, various kinds of insects, amphibians, and reptiles, taken in the 1880's, are in remarkably good condition.

Most of the study specimens in the Survey's collections were made by staff members, who in a sense were monitoring the environment by their collecting programs over the years. As the fame of the collections grew, it was inevitable that private collections would be donated to the Survey for safe keeping. Among the animal groups more than 50 major collections have been deposited here. The earliest for which we have a record consists of approximately 6,000 beetles and bees given to the Survey in 1881. The most recent were last year when a private collection of 20,800 mussels from Illinois rivers was presented; some 10,000 vials of caddisflies, ants, and scorpion flies were bequeathed, and more than a quarter of a million pinned insects were transferred to us on permanent loan by the University of Illinois. All study specimens have complete collecting data.

The outstanding collections at the Survey are those of insects with over four million specimens and fishes with about a half-million, but other small collections represent fungi, flowering plants, mollusks, spiders, and other vertebrate groups. A special collection consists of soybean-associated arthropods from all parts of the world where soybeans are grown. It and some of the other noninsect groups are being computerized in order to facilitate rapid retrieval of valuable data. The reference material is the official State collection, and one of the responsibilities of this agency is the proper maintenance of the collections.

Thrips in Soybeans

The soybean thrips, *Sericothrips variabilis,* is commonly found in soybean fields throughout the Midwest and it approached pest status in Illinois for the first time in 1975 when numbers reached epidemic proportions. The stress exerted by thrips on soybean seedlings, especially in the southern third of the state, was compounded by stress caused by herbicide injury. As leaves

of seedlings curled and dropped, farmers became concerned and began treating with insecticides. Within the major zone of infestation about 1.5 million ha (hectares) of soybeans were planted. Of those, over 50,000 ha were treated with insecticide to control soybean thrips. At the time of the outbreak, little was known about the soybean thrips and their impact on soybean quality and yield. Some species of thrips are known to be involved in the transmission of bud blight disease of soybeans, caused by tobacco ringspot virus. This disease can dramatically reduce soybean seed quantity and quality. Survey entomologist M. E. Irwin began a study of thrips in soybean fields in 1975 and has discovered some facts that could lead to an improved understanding of the role of thrips in soybean production in Illinois.

Under laboratory conditions Irwin and S. E. Halbert, a graduate student, have shown that the soybean thrips is probably incapable of spreading bud blight disease to soybeans. A study was initiated between Irwin of the Illinois Natural History Survey and the University of Illinois, K. V. Yeargan, University of Kentucky, and N. L. Marston, United States Department of Agriculture, Missouri, to determine the species composition and the spatial and temporal distribution patterns of thrips in soybean fields in the Midwest.

Two species of phytophagous thrips — the soybean thrips, *Sericothrips variabilis,* and the flower thrips, *Frankliniella tritici* — colonized soybean plants in the area. Numbers of thrips were similar no matter which part of the fields were sampled. However, both species were unevenly distributed on the soybean plants. Larvae and adults of the flower thrips were concentrated in terminal buds and blossoms. Adults of the soybean thrips were found most commonly on the uppermost fully expanded leaf or on the leaf immediately below it. Larvae of the soybean thrips were generally concentrated on the 3rd–6th leaves below the terminal. Both species occurred in soybean fields throughout the growing season. Populations of the flower thrips peaked earlier than did those of the soybean thrips. Early season population densities of both species were higher, and rates of population buildup and decline were more pronounced in Kentucky than in either Illinois or Missouri.

Moderate infestations of certain species of thrips early in the growing season may be economically beneficial. Preliminary results strongly suggest that the density of *Orius insidiosus,* an important general insect predator, in soybean fields is directly correlated with buildup of colonizing thrips. After thrips population levels are suppressed by the predator, *O. insidiosus* seems to act as a buffer to the buildup of other soybean pest species because it preys on their eggs and small larvae. Irwin is currently studying the interaction of thrips and *Orius* in soybeans with the thought that a better understanding of these two major groups of insects in soybean fields could be used to help reduce pest problems throughout the growing season.

Computers at the Library

LCS is the new acronym being used at the University of Illinois Library. It stands for the Library Circulation System, which is now computerized. As a departmental library of the University of Illinois, the INHS Library has a computer terminal that is wired directly to the data base containing the shelf list of the entire U. of I. Library. It can be searched by author, title, author–title or call number. If the work being searched is located in the library system, the terminal prints out its call number, author, title, place and date of publication, location, circulation period, and whether it is charged out, has saves on it or is on the shelf ready to circulate.

If the book a researcher needs is located in the main library or another departmental library, it can be charged out to him/her remotely on the INHS Library terminal. The book can then reach the researcher in one of three ways: (1) the researcher can wait a few hours and go pick it up at its location, where it will be waiting; (2) it can be sent to the INHS Library through the shipping department of the U. of I. Library; or (3) it can be mailed to the researcher through campus mail.

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The INHS Library computer terminal is also wired to be used with an acoustic coupler to reach literature data bases through long–distance telephone lines. The University of Illinois Library subsidizes searching on BRS) Bibliographic Retrieval System), which contains data bases such as Biosis Previews (publishers of Biological Abstracts and Bioresearch Index), Agricola or Cain (National Agriculture Library), Dissertation Abstracts, Pollution Abstracts and National Technical Information Service. These data bases can be searched very reasonably with the U. of I. Library subsidization. Royalty data bases cost $10 per half–hour on–line and non–royalty data bases are only $3 per half–hour on–line. Back files can be searched off–line at night when the data bases are unavailable for on–line use. The citations retrieved in this way can be printed on–line the next day at the on–line rate or mailed to the Library at the rate of 16¢ per page. Most of the data bases contain citations to literature from about 1970 to the present. This makes them very valuable as a fast literature search for fairly current citations in many subject areas.

BRS is a relatively new vendor and has at this time fourteen data bases for searching. Two of the data bases useful to INHS researchers that are not offered by BRS are Commonwealth Agriculture Bureaux and Aquatic Sciences and Fisheries Abstracts. Consequently, the INHS Library also has a password and account number with DIALOG, the Lockheed Information System.

In the near future the University of Illinois Library will be closing its card catalog and replacing it with a full-bibliographic record on–line. This record will be searchable by every access point, if not more, as the current card catalog, i.e., author, title, subjects, junior authors, series, corporate affiliations. This data base will be searchable in each departmental library, including INHS, as well as many libraries throughout the state.

Computers are great aids in getting the right material to the right person at the right time, and will most likely become more so in the future. With the cost of printing on paper increasing so rapidly, we may find publishers of both primary literature and secondary literature (abstracting and indexing services, bibliographies) making more use of on–line services and less use of printed products. In twenty to twenty–five years we may find scientific research institutions, such as INHS, participating in what Dr. F. W. Lancaster of the U. of I. School of Library Science calls "the paperless society."

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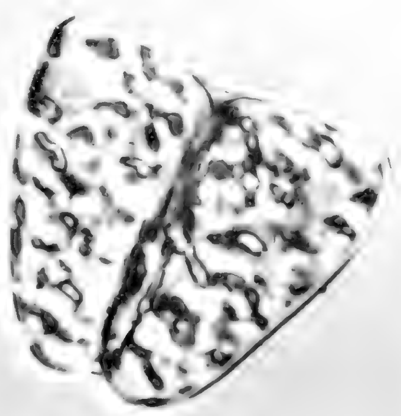
A Newly Discovered Fungus

During an investigation of the fungi that gather on plant debris in cypress swamps in Illinois, a new fungus of the class Ascomycetes was found by mycologists J. L. Crane of the Illinois Natural History Survey and C. A. Shearer of the University of Illinois. This fungus has a closed spore-bearing structure (cleistothecium) and two-celled, brown, butterfly-shaped (papilionaceous) spores, called ascospores, contained in asci, or spore sacs. It is referred to as CS-470. The mycologists will describe this new species in a new genus in the subclass Loculoascomycetes.

The fruiting bodies, which produce spores, are solitary and lie on or near the surface of the material on which the fungus lives, or are embedded in or sunk below the surface, and are globose. The asci are bitunicate (two-walled), globose to somewhat globose, and stalked and lack a subapical chamber. The papilionaceous, two-celled, brown, smooth-walled ascospores uniquely characterize this species. Of the Ascomycetes with bitunicate asci, CS-470 fits best in the Order Pleosporales because of its middle-sized pseudothecia, persistent pseudoparaphyses, septate brown spores, and occurrence on dead twigs.

CS-470 appears to be a rare species that occurs in warm seasons. It was found only once in collections made monthly from three cypress swamps over a 2-year period, and this occurrence was in August 1974. It was collected again in August 1977 in



Newly discovered fungus, CS-470. At the left is the bitunicate (two-walled) ascus (spore sac) magnified 793 times. At the right is the mature butterfly-shaped ascospore magnified 1,833 times.

the same cypress swamp from which it had been collected originally.

Although CS-470 was collected from submerged wood, fruiting bodies developed on the wood after it was incubated in a moist chamber. In addition, submersion of the fungus culture was not necessary to induce fruiting. Even though this behavior is typical of a number of freshwater, estuarine, and marine Ascomycetes, more information is needed about the distribution of this species before it can be characterized as a freshwater Ascomycete.

Managing Waterfowl Habitat Along the Illinois River

The Illinois River valley is one of the nation's most important areas for migrating waterfowl. Long ago, hunters recognized the abundance of waterfowl in the bottomland lakes of the valley, and in the 1890's sportsmen began to acquire bottomland property for the purpose of forming "duck clubs." However, the prohibition of baiting in the mid–1930's greatly reduced the duck kill by private clubs in the Illinois Valley. Although the navigation dams built on the Illinois River in the late 1930's increased the natural food resources for waterfowl, it became necessary for duck clubs to control water levels on their properties to maintain high quality hunting. Water levels are now manipulated by many private duck club and public waterfowl areas.

Water manipulation permits duck food plants to be sown or to volunteer on mud flats during the summer and then allows them to be flooded with water during the fall to attract migrating waterfowl. By 1941, 432 (55 percent) of the 792 duck clubs in Illinois were located in the Illinois Valley. During the late 1950's and early 1960's, thousands of acres of aquatic duck food plants were lost in the valley as increasing sedimentation and turbidity filled shallow productive areas and clouded the waters of the bottomland lakes. As a result of this degradation, the management of water levels by duck clubs and state and federal agencies is now almost mandatory if high quality hunting is to be enjoyed.

Aerial view of land belonging to a private duck club north of Spring Bay, Illinois. Naturally occurring moist-soil plants are grown in the irregularly shaped area in the center foreground. Corn is grown in the other fields. The annual harvest of ducks in the Illinois Valley ranges between 50,000 and 100,000.

The number of waterfowl hunting areas along the Illinois River, their sizes, and management practices were investigated by wildlife specialists Frank Bellrose and Stephen Havera and other members of the Wildlife Research Section at the Havana Laboratory as part of the Lake Michigan Diversion Project that proposes to increase the amount of Lake Michigan water that is diverted into the Illinois River.

The Illinois Department of Conservation issued licenses to 272 duck hunting clubs that managed land along the Illinois River during 1977. In September 1978, a questionnaire was sent to 219 duck clubs that owned 40 acres or more along the Illinois River. A total of 160 (73.1 percent) of the clubs responded, representing 77.3 percent (51,405 acres) of the total area managed by licensed duck clubs in the Illinois Valley. Water levels could be controlled on almost 32 percent (16,315 acres) of the total area managed by the clubs responding to the questionnaire.

The U.S. Fish and Wildlife Service and the Illinois Department of Conservation own 50,478 acres containing 24,344 acres of water in the Illinois River valley. Water levels can be managed on 14.6 percent (7,388 acres) of the total area.

In addition to impoundments where water levels can be controlled, thousands of acres of publicly and privately owned waterfowl areas rely on naturally occurring low water levels during the summer for the establishment of moist-soil vegetation (such as smartweeds, rice cutgrass, wild millet, and beggar ticks) and the planting of agricultural duck foods. Also, sections of federal, state, and private duck-hunting lands are refuge areas where no hunting and little disturbance is permitted during the waterfowl season.

Of the private clubs that responded to the questionnaire and that control water levels, 18 percent managed exclusively for natural moist-soil food plants, whereas 24 percent managed for agricultural crops. Both natural and agricultural food management occurred on 58 percent of the private clubs with water level control. Japanese millet was the most common agricultural crop planted by private duck clubs (59 percent) followed by buckwheat (58 percent), corn (46 percent), soybeans (2 percent), rice (1 percent), and milo (1 percent). State and federal agencies planted primarily Japanese millet, corn, and buckwheat.

State, federal, and private areas control 90,829 acres that are used primarily for waterfowl hunting and management, representing approximately 43.2 percent of the 210,000 acres of nonleveed floodplain in the Illinois Valley. The remaining 190,000 acres of the floodplain are in levee and drainage districts primarily for agricultural purposes.

New Concepts on Black Cutworm Field Biology

The black cutworm, *Agrotis ipsilon,* is a cosmopolitan insect that attacks at least 49 species of field and vegetable crops. The larval or worm stage of this insect is dark brown to black and is approximately 2 inches long and about pencil thick. The larvae cause damage by severing seedling plants or chewing into stalks, roots, bulbs, and tubers. These worms are especially damaging to corn throughout Illinois during May and early June. The complete life history of this insect is not known for the north-central region of the United States, and no criteria have been available for predicting infestation and damage.

During the growing seasons of 1974

Black cutworm larva found beneath a chickweed plant in a field before crop planting time.

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through 1977 a total of 38 corn fields damaged by the black cutworm were intensively studied by economic entomologists Dan Sherrod, John Shaw, and W. H. Luckmann. Two new concepts concerning the field biology of this insect resulted from these studies. The first concept is that black cutworm larvae damaging seedling corn in May and June originate from eggs oviposited in the field in the spring before the corn is planted. By collecting and sizing larvae from the study fields and applying predictive techniques based on temperature data, they determined a theoretical oviposition date. In almost every case the predicted oviposition date preceded the planting date for each field. These larvae that hatch prior to corn emergence must have some source of food until the corn is available. They found that spring weed plants growing in the field could fill this need.

This point forms the second concept: agronomic practices which encourage the establishment of weeds, especially winter annual and perennial weeds, increase the potential for the presence of the black cutworm. In 1976-1977 fields that had a history of problems with black cutworms were monitored by regularly visiting the fields from February through May in an attempt to detect infestations before corn planting time. Larvae were observed in April and May around clumps of common chickweed, *Stellaria media,* and mouse-eared chickweed, *Cerastium vulgatum vulgatum.* Usually, one or more larvae could be recovered by digging in the soil around the base of a chickweed plant. In Illinois chickweed is classified as a winter annual which germinates and establishes itself in the fall. It grows during the winter and flowers in late February and in March. Chickweed and other winter annuals are most likely to occur in fields where soybeans were grown in the previous year and where the soil has not been disturbed or has been disturbed in a minimal way through conservation tillage.

The proposed concepts are based on the best data currently available. The black cutworm is a difficult pest to predict, and considerable additional information on cutworm biology and behavior and on field ecology will be needed before good detection and control programs can be refined. The concept on the significance of weeds is very applicable to conservation tillage systems often used for corn following soybeans. Weediness also increases in the spring due to extended periods of rainfall when fields cannot be timely prepared and planted. The concept that the larvae that damage seedling corn are in the field before the seed is planted reflects the reality of field observations and field problems.

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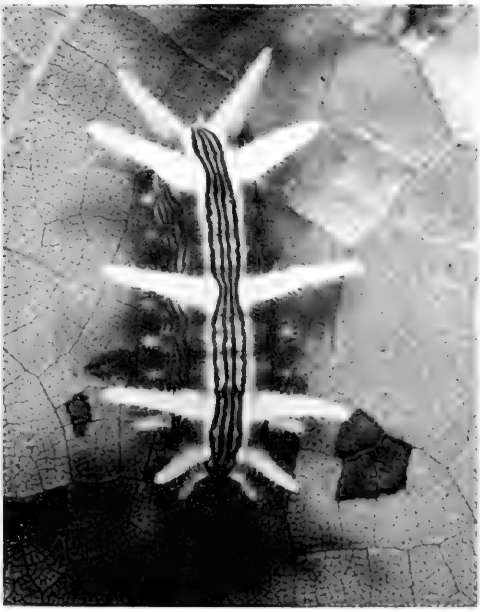
Stinging Caterpillars

The concern of people when they encounter caterpillars feeding on garden plants, trees, and field crops primarily focuses on the economic or aesthetic damage that the caterpillars may cause. They rarely are considered as potentially and directly hazardous to human comfort. The vast majority of caterpillars brought to the Illinois Natural History Survey for identification are various species of cutworms and armyworms. These can be safely picked up with bare fingers, and the most that the handler may anticipate is being nipped by the caterpillar's mandibles. Unfortunately the same cannot be said of stinging or urticating caterpillars that can cause reactions ranging from mild itching and stinging sensations to a variety of more serious symptoms, for example inflammation of lymphatic tissue, that may be accompanied by considerable pain and swelling of extremities.



Stinging rose caterpillar (*Parasa indetermina*) on a leaf (Photo by Les Woodrum, Survey Photographer).

Several species of urticating caterpillars occur in Illinois. Examples of them include the larva of the io moth (*Automeris io*), the puss caterpillar (*Megalopyge opercularis*) and about 20 species of slug caterpillars. Many urticating caterpillars feed on a variety of cultivated shrubs and trees, but frequently go undetected. The ones most likely to attract the attention of the curious gardener or horticulturist are some of the slug caterpillars because of their bright, gaudy coloration.

Slug caterpillars belong to the lepidopterous family Limacodidae. Their sluglike appearance is caused by a retracted and partially concealed head, inconspicuous thoracic legs, and abdominal prolegs that are vestigial or absent. As a result slug caterpillars seem to glide rather than walk. Some of the species are smooth and lack tubercles or spines while others such as the rather common saddleback caterpillar (*Sibine stimulea*) and the stinging rose caterpillar (*Parasa indetermina*) bear prominent fleshy tubercles that are covered with numerous spines.

Neither the relative toxicity of each species of slug caterpillar nor the nature of the toxin has been documented adequately. It is known that the spines on the body of slug caterpillars contain a substance that is released when the spines pierce and break the skin of an unsuspecting person. Not all reactions are chemi-

cally caused because some species of urticating caterpillars bear types of setae or hairs that contain no toxin but instead are minutely barbed and can mechanically cause irritations.

There is no reported outbreak of slug caterpillars and other urticating caterpillars in Illinois. However, because they may be found in a variety of outdoor and crop situations, persons finding slug caterpillars should handle them cautiously with tweezers or forceps. Anyone needing identifications of troublesome caterpillars may send or bring them in vials of alcohol to George L. Godfrey, Section of Faunistic Surveys and Insect Identification, Illinois Natural History Survey, 172 Natural Resources Building, Urbana, IL 61801.

A Leaf Miner in Soybeans

Many specimens of small dark red beetles were present in surveys of arthropods associated with soybeans made since 1969. These were determined to be *Odontota horni,* hispine beetles whose larvae formed blotch mines in leaves of native legumes such as *Amphicarpaea bracteata* var. *comosa, Desmodium illinoense, Tephrosia virginiana,* and *Meibomia rigida.* When soybean plants were searched, the blotch mines and larvae were found in the field.

Survey entomologist Marcos Kogan and his student assistant, Dan D. Kogan, studied and published on the life cycle and feeding habits of the adults and the larvae of this beetle in Illinois. The adults feed on the leaves leaving the veins intact, thus skeletonizing the leaf. The egg is inserted, usually singly, under the epidermis of the leaf usually on the lower surface. The larvae emerge after about six days and feed on the parenchyma near the egg forming a mine between the upper and lower surfaces of the leaf and feeding outwards from the position of the egg in all directions unless a major vein or leaf margin is encountered. The larvae when mature enter a pupal stage in the mine and the three larval and the pupal stage take about 25 days. Two generations per year probably occur in Illinois.

The potential of this species to cause economic damage to soybeans in Illinois is slight. However, the beetle may have to be taken into consideration if other more serious pests are also present and approaching the economic injury level.

From the viewpoint of the evolution of the arthropod fauna associated with soybeans in the New World, *O. horni* exemplifies a tendency also shown by the Mexican bean beetle and the bean leaf beetle. These are all oligophagous (feeding on few hosts) species with host ranges limited to a few genera of the plant family Leguminosae. *O. horni* seems to prefer *Amphicarpaea* and *Desmodium* as the natural hosts. Since *Amphicarpaea* is considered to be the closest New World relative to the soybean, the transition of this beetle would have been predictable. Documentation of a gradual adaptation of native legume fauna to the soybean as it is introduced into new regions has both practical and theoretical aspects.

Submersible Vacuum Cleaner

Taking accurate and reliable samples of aquatic microorganisms has been a historical stumbling block for many aquatic ecologists. Although many types of devices, ranging from simple water bottles to elaborate pump systems, have been designed and modified since the mid–1800's, the recent demand for more stringent environmental assessments and answers to specific ecological problems has resulted in the development of improved sampling instruments.

Faced with the need for an apparatus that samples zooplankton with repeatable precision from rivers and power plant cooling lakes, as well as most other aquatic habitats, aquatic biologists Stephen W. Waite of the Natural History Survey and Scott O'Grady of the University of Illinois developed a design that combines some of the best features of two major types of zooplankton samplers: the plankton net and the pump sampler. In most cases, pump samplers have been proven superior to other types of equipment for general use. They provide a reliable measure of the water volume sampled and are proficient in coves, shallow depths, and tur-

Submersible vacuum pump collecting equipment with battery in boat (Photo by John Barlow, Aquatic Biologist).

bulent waters. Nets, on the other hand, provide a convenient means of reducing the mass of organisms present in large volumes of water to smaller, more easily handled, concentrated samples.

Therefore, the priorities for a new apparatus included the following objectives: to incorporate and enclose both a battery-operated pump and a high speed plankton net within a single submersible unit, readily obtainable materials in the sampler's construction, and to create a basic design that can be readily modified for a variety of specific sampling requirements. The design of the new apparatus is relatively simple. It consists primarily of a pump assembly, a filtering unit, a box-like structure that provides support for the whole apparatus, and a portable power supply (battery) which is separate and remains with the operator.

Prior to operation, the filter-pump apparatus is lowered into the water and allowed to fill. The pump is activated with a remote switch and the gear is raised and lowered or held at a specific level in the water depending on the sampling regime. At the end of the required time interval, the apparatus is raised out of the water where the netting is thoroughly rinsed. The sample is retrieved by removing a brass plankton bucket from the rear of the sampler and rinsing the organisms into a bottle containing preservative.

Although the original apparatus was designed to sample zooplankton, its size and shape can be easily altered to collect other types of organisms including algae and stream macroinvertebrates. The uses of this sampler are many and vary according to the research needs.

Mercury and Lake Shelbyville

The analysis for mercury in largemouth bass and walleye collected from Lake Shelbyville in central Illinois in 1974 touched off an investigation of the lake's level of mercury contamination. Fish collected at that time had mercury concentrations substantially higher than those found in fish collected from other lakes in the same region of the state and several exceeded the 0.5 ppm Food and Drug Administration guideline. Reports of these results, with confirming analysis of the same samples by another laboratory and the collection and analysis of additional samples, caused the Illinois Department of Conservation to issue a warning to fishermen about consuming excessive amounts of these fish. During the next two years, fish from Lake Shelbyville continued to show similarly high mercury concentrations and the warnings were reissued annually.

In 1977, a two year investigation of the lake was begun by Survey analytical chemist Kenneth E. Smith and his associate Aaron P. Griffith under joint funding from the Illinois Natural History Survey and the Illinois Institute of Natural Resources. The study was to determine if a point

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source, or sources, could be found for the mercury contamination and to determine the bioaccumulation occurring in the lake's aquatic ecosystem.

Seventeen sampling sites were established to cover major tributary streams as well as central areas in each of the three arms of the lake. Water samples were collected monthly from each station, as well as samples of bottom sediment, clams (when present), zooplankton, and five species of fish. For the tributary stations, samples of terrestrial soil were collected 2-3 kilometers upstream from each tributary's mouth. All samples were analyzed for total mercury and results were interpreted with the aid of statistical tests.

The results indicated that there was not a distinguishable point source, or area, which was contributing the mercury contamination to Lake Shelbyville. Results of the analysis of the biota collected from the lake also were not indicative of a contamination in one area of the lake.

The bioaccumulation of mercury in the lake's food chain was determined from the results of the analysis. Beginning with water as a background value, and continuing through the plankton, clams, and lower trophic level fishes to the major predators, a steady accumulation was found. Normalizing the mean mercury concentration of the plankton as 1 and expressing the concentrations of the other biological organisms as multiples of this factor yield the following bioamplification scheme: plankton (1), clams (2), gizzard shad (7), bluegill (10), carp (21), largemouth bass (20), and walleye (30).

Since 1974, a highly significant correlation has existed for the predator species between their size and the concentration of mercury in their tissues. In 1974 this regression predicted that bass over 0.5 kg would exceed the FDA 0.5 ppm guideline, while the regression for the bass collected in 1978 predicted this size to be 2.2 kg at the same level of confidence (99% level). The same trend was seen for walleyes, beginning at 2.0 kg for the 1975 collection and rising to 3.1 kg for the 1978 collection. This indicates that the level of contamination is decreasing and soon may no longer be a problem for the fishermen.

A postulated mechanism for the mercury's entrance into the aquatic ecosystem involves methylation of mercury absorbed on soil once the soil is flooded and enters an anaerobic system. As mercury in the now lake-bottom soil is depleted, less mercury would be available to the biota of the lake and once methylated, various pathways would be available for removal of mercury from the aquatic environment.

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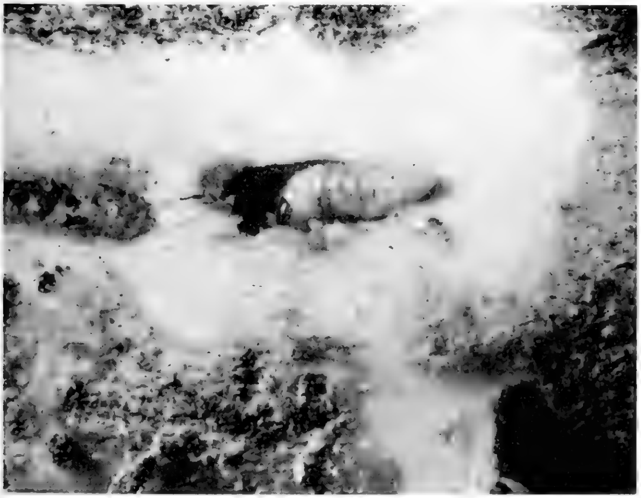
Control of the Imported Crucifer Weevil in Horseradish Planting Stocks

In 1977 the imported crucifer weevil, *Baris lepidii* Germar, was discovered infesting fields of horseradish in St. Clair and Madison counties. Previously, this insect had been considered an occasional pest of crucifers only in central Europe and the USSR. The adults feed on stems and roots and lay eggs in tissues of primary and secondary roots. The white, grublike larva is the most damaging stage because it tunnels in the roots.

Horseradish is produced for its fleshy, pungent roots. The method of growing horseradish greatly influences the spread and establishment of this weevil. Horseradish is vegetatively propagated by planting 30- to 35-cm pieces of pencil-thin secondary roots ("sets") in early spring. The crop is harvested in late fall and in the succeeding spring. Primary roots are sold for processing, and sets are stored in underground soil pits or in cool cellars to be used for planting in the spring. Many root pieces remain in the soil following the harvest, producing extensive patches of horseradish in rotation crops in the succeeding year. Horseradish is usually rotated with other crops and is planted on the same land every other year.

The imported crucifer weevil overwinters in Illinois as adults, eggs, and larvae in unharvested or volunteer horseradish and as eggs and larvae in stored sets. Infestation of the commercial horseradish crop occurs through the dispersal of weevil adults from infested volunteer horseradish and through the planting of sets containing eggs and larvae.

Illinois Natural History Survey economic entomologists R. E. Foster, Dan Sherrod, Cathy Eastman, and Roscoe Randell investigated procedures for reducing field



An imported crucifer weevil, *Baris lepidii,* larva in a typical feeding channel in a horseradish root.

infestations of the imported crucifer weevil by the destruction of eggs and larvae in horseradish sets. They evaluated techniques using hot water dips, fumigants, and insecticide dips.

The entomologists sum up their findings in this way. Dichlorvos as a dip or a fumigant proved ineffective at killing eggs of the imported crucifer weevil. Hot water treatments showed promise but should be abandoned because of the difficulty of maintaining precise water temperatures for large commercial crates of sets. Fumigation with methyl bromide also appeared promising but would require further research to make it usable by growers.

Immersing the sets in permethrin was the most useful method tested. While this treatment had little effect on larval survival, egg mortality was high. Eggs were by far the most numerous stage present in sets, and a recent examination of sets showed that few larvae survived the winter. Set sprouting was not affected by treatment with permethrin at concentrations of 0.1 to 0.5 percent for exposure times of 30, 60, and 120 minutes, and by the end of the growing season only minimal permethrin residues persisted in the roots.

Breaker, Breaker. Come in, Good Bassy!

For more than 20 years Survey biologists have been tracking all sorts of animals from hawks to squirrels and, more recently, fish. The imagination and engineering skill of William Cochran, wildlife specialist, in developing tiny radios that can be attached to these animals have permitted following them in the air, on the land, and in the water. In 1970, working with fishery biologist Weldon Larimore, Cochran designed a radio that could be surgically implanted in the body cavity of a fish. The small radio with its battery and loop antenna resembles a small padlock about 1½ inches long.

The Survey's first extensive fish radiotracking program was in Lake Sangchris, a power-plant cooling lake in central Illinois. The biologists were interested in how largemouth bass moved from day to day through the seasons and how they responded to the warm water being discharged into the lake by the power plant. About the same time a companion study was being conducted at Lake Shelbyville, a main-stream impoundment where water levels fluctuate throughout the year. How bass responded to changes in water level was the primary objective of that study.

Recently a new and more sophisticated radiotelemetry study has been initiated in the Salt Fork River of east-central Illinois, where Dr. Larimore is following the movements of smallmouth bass. Although these small radios developed by the Natural History Survey have been used in coldwater rivers of the West to follow the extensive movements of salmon and trout, no such work has been done in our more turbid, warmwater streams, and nearly all Illinois streams are of this type. The specific area of the Salt Fork being studied is a 15-mile stretch southwest of Oakwood in Vermilion County. When a smallmouth bass has been selected for the experiment and the small radio has been surgically implanted in the body cavity, it is given a numbered 2-inch long piece of yellow plastic tubing that is attached to the fish's back. On this tubing are the fish's number and a telephone number that can be used if the fish is caught by an angler.

Each radio put in a fish is on a different frequency so that the fish can be identified when a biologist picks up a transmitted signal. The actual tracking of the fish, a search for each fish with its distinctive signal, is done through two systems. In one system the biologist simply moves up and down the river "listening" for the radio signal to show the exact location of an experimental fish. The other system is more complicated; it includes a tall fixed receiving antenna that can pick up signals over a mile or so of stream. The signal is then recorded automatically on a chart.

What is this research all about? Dr. Larimore is trying to associate the daily activities and seasonal movements of our sport fishes with their breeding and feeding requirements, and to understand their responses to changes in water conditions,

Miniature radio transmitter about to be implanted in the body cavity of an anesthetized bass.

such as increased turbidity and water levels during flood periods or drastic drops in water flow during droughts. He will be able to observe the responses of fish to changes in water quality, such as pollution, that might cause the displacement of river fishes.

There are many interesting and exciting potentials for this work, and Dr. Larimore is anxious to have the help of fishermen that fish this river. Their cooperation can add tremendously to the research results. It is hoped that these special fish will be released after the fisherman has noted the tag number and the telephone number. A call to the fishery laboratory would then provide valuable information and save the experimental fish. If, however, the fish is accidentally killed by hooking or dies before the tag is noticed, the angler is encouraged to save the tag from the back and the radio from inside the fish and then report his catch. Because the cooperation of fishermen is so important to this study, they are encouraged to call the Survey at (217) 333-6890 to ask questions or further discuss the work. As this research progresses biologists may be able to tell fishermen where to look for bass during different times of the year and under different conditions. Certainly the biologists should learn more about the habitat requirements of our river fishes and ultimately be able to protect and improve habitats in our Illinois rivers.

Measuring Migrant Bird Populations

The large numbers of transient birds that pass through Illinois each year probably have an important influence on the habitats they use, yet absolute measurements of these populations are virtually nonexistent. Students of bird populations have concentrated on studies of breeding and, to a lesser extent, winter populations. There are at least two reasons for this choice of seasons: (1) the obvious importance of the breeding cycle (i.e., productivity) and winter survival on the ecology of species, and (2) the fact that nesting and winter populations, once established, are relatively stable from day to day. By contrast, the ephemeral nature of the transient populations has made censusing seem impracticable.

The transect census technique developed by the Illinois Natural History Survey's early investigators, Stephen A. Forbes and Alfred O. Gross, is potentially a useful method of measuring transient bird populations. In April and May 1979, ornithologists Richard and Jean Graber applied the technique to measure populations of birds in arboreal habitats in southern and central Illinois. The investigators were concerned that the numbers of transients present on some days would overwhelm their capability to detect and record. Daily censuses in April and May proved the method workable for even the highest

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populations encountered, and the census will be continued through the fall and next year.

The pressure which the transient populations exert on a habitat can be seen in a comparison of the density of the population in April and May with that of the June breeding population. For example, in a bottomland forest tract with a breeding population of 40 bird species and a density of 266 birds per 40.5 hectares (100 acres), the average daily population of transients was composed of 58 species at a density of 571 birds per 40.5 hectares, i.e., more than twice the breeding population. The pressure of these populations on the habitat might be more realistically expressed in terms of biomass or the metabolic requirements of the animals involved. In either case the comparative pressure of the transients might be somewhat lower than the densities suggest because many of the species (e.g., warblers) are small.

It is also necessary to note that the breeding densities referred to above do not include young that are produced on the area, a component which would definitely swell the importance of the breeding population (to an unknown, but calculable, level).

With just the data from the spring censuses, it is already clear that transient bird populations are of great importance to Illinois habitats, and vice-versa. An important practical question that needs consideration is whether, and to what extent, the transients affect the resources of the breeding bird populations.

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Least Darter Biology

At the turn of the century, 26 species of darters occurred in the streams and lakes of Illinois; however, only 23 are known to remain. Of these 23, ten have been the subjects of life-history studies conducted by present and past Survey personnel over the last 12 years. The latest study to be completed and published by former Survey ichthyologist B. M. Burr and Survey ichthyologist L. M. Page concerns a tiny species called the least darter, *Etheostoma microperca*. The least darter has a moderately large range in eastern North America and reaches its greatest abundance in the Great Lakes region. The population chosen for study was in a small, unnamed tributary of the Iroquois River near Watseka in Iroquois County, Illinois. The tributary was a narrow, shallow creek with grass-covered banks and, during the summer months, thick growths of filamentous algae.

One year of field and laboratory work revealed that the least darter has a life history similar to that of the closely related cypress darter. In Illinois the least darter reaches a maximum length of 32 mm and lives a maximum of only 20 months. Like the cypress darter, the least darter has a deeply indented egg, an unusual feature among freshwater fishes which generally have spherical eggs. At one year of age and mostly during the month of May, the least darter spawns in filamentous algae close to the edges of the stream. The male mounts the back of the female, grasps her with his large cuplike pelvic fins, and then the two ascend to the site of egg deposition. The spawning pair usually assumes a vertical position and one to three eggs are laid at a time. Eggs are left unattended and, at 20°C, hatch in about 7.5 days. Growth is rapid for the first six or seven weeks. By October, the population reaches its peak density with as many as 33 darters per

Least darters spawning (Photo by Brooks Burr, Southern Illinois University at Carbondale).

square meter of stream bottom. The diet consists principally of larval midge flies and small crustaceans.

Public awareness of the importance of nongame fishes in the overall maintenance of diversity and stability of aquatic ecosystems has made the INHS life-history studies all the more valuable. In fact, the Survey has become established as one of the centers for the study of fish life histories. Future proper management and protection of Illinois' nongame fishes will depend in large part on the rational use of baseline data presented in such life-history studies. Copies of the publication on the least darter, *Biological Notes* No. 112, are available upon request to the Survey.

Wood Duck Populations

The wood duck population on the Quiver Creek study area rebounded in 1979 after a serious decline in 1978, according to Survey wildlifer Frank Bellrose. There were 113 nests in 1979 compared with 86 in 1978, and nest success in 1979 was 63.7 percent compared with 31.1 percent in 1978. In 1978 only 39 percent (15) of the incubating hens were new ducks, but despite the poor hatch in 1978, 46 percent (34) of the incubating hens were new in 1979.

In most instances new hens are yearlings hatched on the area the previous year. Yet there are these incongruities: in 1977, there was a 78 percent hatch of 166 nests, but only 15 new hens turned up in 1978. Of 1,013 ducklings marked in 1977, none was found in 1978 or in 1979. To further cloud an understanding of what occurred, 22 incubating hens banded on the nest in 1976 and 1977 appeared in 1979 after failing to put in an appearance in 1978.

It appears that a high loss of young occurred in 1977 that almost eliminated the return of yearlings. This loss was further compounded by the unprecedented nesting by older hens off the study area in 1978. A study of previous records indicates that in the past 26 years an average of four hens per year nested outside the study area or were not found if they nested on the study area.

Is there a relationship between the hens that were not found nesting in 1978 and the disappearance of hatched young during the summer of 1977? That summer, 67 sick wood ducks were noted on the study area, by far the largest number of ill ducks ever noticed. Did their behavior alarm other ducks, causing them to nest elsewhere in 1978 but return in 1979?

Average survival of nesting wood duck hens over a period of 20 years is 49 percent. Between 1976 and 1977 it was 66 percent, between 1977 and 1978 it was 30 percent, and between 1978 and 1979, it was 50 percent. Clearly an unusual mortality unrelated to hunting decimated the Quiver Creek wood duck breeding population between the 1977 and 1978 nesting seasons.

Walnut Caterpillars and Wood

Black walnut is the most important timber and nut tree species grown in Illinois. Because of the increased demand for walnut lumber, there has been a drastic reduction in the natural stands of this tree. In recent years an increased interest in planting walnut trees has occurred. Insects can often cause problems in such plantings. Of the insects which feed on walnut foliage, the walnut caterpillar is the most serious. When the walnut caterpillars are abundant, complete defoliation of trees often occurs, thereby weakening the trees and making them more susceptible to insect borers which destroy the quality of the wood and can result in the death of the trees. Through a research project funded by the USDA Forest Service and The Joyce Foundation, Survey entomologists, Marion Farris and James Appleby, conducted studies on the life history of the walnut caterpillar. They found that the female moth always deposits its eggs in clusters on the lower leaf surface. Tiny wasps often parasitize such egg masses and during certain years may account for 26 percent of the eggs not hatching. After the eggs hatch the walnut caterpillar larvae are often attacked by predaceous stink bugs and wheel bugs. Certain flies and wasps will sometimes lay their eggs on the

On the left is a mature walnut tree defoliated by the walnut caterpillar (Photo by M. E. Farris). On the right is a group of walnut caterpillars on foliage of walnut tree (Photo by J. E. Appleby).

caterpillar or insert their eggs within the caterpillar's body. The parasitic larva develops within the caterpillar's body, eventually resulting in its death. The adult fly or wasp will emerge the following year and search out other walnut caterpillars to parasitize. The walnut caterpillar is generally controlled by its natural enemies; however, periodically the insect's natural controls are ineffective and populations of the walnut caterpillar become epidemic. To prevent such outbreaks growers may have to resort to using insecticide sprays for control. Experiments were conducted at the Dixon Springs Agricultural Center in southern Illinois to find insecticides that would be effective but would not have adverse environmental effects. Farris and Appleby found that insecticides such as acephate (Orthene), *Bacillus thuringiensis* (Dipel), diazinon, and malathion were effective in controlling the caterpillars. Through such studies the walnut grower will now have a better understanding of the walnut caterpillar so that the walnut seedlings of today will eventually grow to maturity and become walnut furniture of the future.

Redear Sunfish in Illinois

Redear sunfish, *Lepomis microlophus*, originally were inhabitants of the southeastern states. They were introduced into Illinois in 1946 to supplement the state's sport fishery. Reservoirs and ponds throughout the state were stocked with this species, but the deep, warm-water lakes provided the most suitable habitat for the redear. Stocking resulted in self-sustaining populations in most of these lakes, and the fast-growing redear became an established sport fish.

The redear populations in some Illinois lakes have recently declined, and in other lakes have totally disappeared. The cause for these changes, whether inherent to the species or its habitat, is not apparent.

Survey aquatic biologists Dee A. McCormick and Warren U. Brigham conducted an extensive literature review of published and unpublished works on the life history of the redear sunfish with Dingell-Johnson funds through the Illinois Department of Conservation. The primary objective of the study was to determine which factors limited redear sunfish in Illinois waters. The report concluded that these fish are limited in Illinois primarily

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by temperature and competition. Temperature may limit the species by substantially reducing its reproductive success in northern waters. The shorter spawning season in Illinois commonly limits redear to one spawn per year. Redear may spawn throughout the entire summer in southern portions of its range. In addition, juvenile redear may not be able to endure the low temperatures common to northern and central Illinois winters in shallow lakes.

Competition for food and space may limit the species in habitats which are less than optimal for redear success. The lakes and ponds of Illinois which contain stocked redear populations commonly are more turbid than those in which redear naturally occur. The low light penetration in turbid water limits the depths to which aquatic plants grow and may force the redear into weedy shallow water where they must compete with other sunfish for food and space.

The effects of temperature and competition on redear have not been studied in detail. Survey aquatic biologists are proposing a comprehensive field study to determine the nature and degree to which temperature and competition limit redear sunfish populations in the lakes of Illinois. Upon completion of this investigation it will be possible to formulate an effective management plan for the redear sunfish in Illinois. Such a plan will make it possible to restrict the stocking of redear sunfish to those lakes providing favorable conditions for the species and to enhance its status as a sport fish.

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The Illinois

NATURAL HISTORY SURVEY REPORTS

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A Treatment for "Anemic" Trees

Yellow foliage (chlorosis), sometimes caused by iron deficiency, and slow growth are typical of many trees planted along streets and around homes where the original topsoil has been removed or mixed with the subsoil. The average urban soil has relatively poor physical, chemical, and biological characteristics. Tree root development and penetration are greatly reduced in heavy clay subsoils that lack adequate aeration and water drainage. Additionally, the amount of available nutrients and organic matter is often critically low. Agronomically, urban soils are usually a conglomerate of rubble.

Trees growing under urban conditions frequently exhibit nutrient deficiency symptoms. When these symptoms occur, they are often difficult to diagnose. However, plant pathologist Gene Himelick has found that correcting the deficiency is inexpensive and may be effective for 2, 3, or even 4 years. If affected trees remain untreated they usually continue to decline, but systemic treatment for chlorosis will prolong the life, improve the vigor, and increase the aesthetic value of a tree.

Most urban trees manage to survive for at least a few years despite poor soil conditions and other environmental stresses. In Illinois, chlorosis is a common problem of pin, red, and white oak; bald cypress; sweet gum; river birch; silver and red maple; and hackberry. Occasionally it occurs on American sycamore.

In tests begun in 1974, Himelick and his associates tested ferric citrate powder and commercially prepared capsules (Medicaps) containing ferric ammonium citrate; highly soluble nitrogen (N), phosphorus (P), and potassium (K); and a slow-release nitrogen source as possible corrective treatments for chlorosis. Six tree species were used in the tests: pin oak, bald cypress, red oak, swamp white oak, sweet gum, and American sycamore. The trees were located on the Urbana campus of the University of Illinois and were 6–40 inches in diameter at breast height (dbh).

A plastic syringe was used to inject the ferric citrate powder into small holes drilled 4 inches apart around each tree trunk. The commercially prepared gelatin capsules were enclosed in slotted plastic coverings and were driven into holes drilled about 6 inches apart around the trunks of trees to be treated.

The ferric citrate treatments were effective on pin oak, cypress, red oak, swamp white oak, and sweet gum. Only slight response was obtained on American sycamore.

In 1977 the test was expanded to include pin oaks and sweet gums growing on parkways in Urbana.

In this test, pin oak responded well to all treatments with iron compounds and to combinations of iron and nutrients. The sweet gum response to all treatments was generally not as definite as those obtained on pin oak. Trees treated with ferric citrate responded best and, in general, the distribution of the compound appeared better than in other treatments. The combination of ferric ammonium citrate and soluble NPK gave slightly better color response in pin oak than did the use of the iron compound alone. Some response was

A pin oak showing advanced symptoms of chlorosis, or yellowing of the foliage. Systemic treatment with iron compounds generally corrects the iron deficiency.

achieved through the use of soluble NPK in both pin oak and sweet gum, but the use of slow-release N alone gave no measurable response.

White oaks that had been chlorotic 2–6 years growing on parkways along streets in Highland Park were treated to determine if they would respond to either iron or manganese. The trees (average dbh, 20.8 inches) were treated between May 4 and 8, 1978. Color ratings were made on June 7 and August 1, 1978, and August 23, 1979.

The color response at the end of the first and second growing seasons was relatively poor. There appeared to be no difference in color response between the use of iron and of manganese.

The use of ferric citrate as a powder or ferric ammonium citrate as Medicaps provides a reasonably effective and economical way of treating large chlorotic trees. The results of treatment have been more pronounced in trees showing advanced stages of chlorosis than in those exhibiting early stages. However, it is advisable to begin treating chlorotic trees before they have advanced to the later stages of chlorosis and decline.

Proper timing of the treatment is important in correcting chlorosis. Treatments completed in late summer generally were not effective until the following year, and the treatment lasted only 1–2 years. Late-dormant or April and May treatments have been found to be most effective, and the treatments last for 3–4 years.

For specific information on how to treat

chlorotic trees, contact the Botany and Plant Pathology Section of the Illinois Natural History Survey.

Testing the Toxicity of Ammonia to Illinois Fishes

Under the Clean Water Act, a national goal is the attainment of fishable, swimmable waters, wherever possible, by 1983. To achieve this goal, water quality standards must be set which will limit pollutant concentrations to levels that will protect aquatic life. On the other hand, complying with the standards in the treatment of wastewaters discharged into streams may be costly. Thus, the standards should not be more stringent than is necessary to protect aquatic life.

Most studies on effects of pollutants on fishes have been done with a few species, especially trout, and for exposure times of only 2–4 days. There is a scarcity of information on the water quality requirements of most Illinois fishes, particularly for exposure times of more than 4 days.

Recently aquatic biologists Keturah Reinbold and Richard Sparks, with their associate, Stephen Pescitelli, began a study of the toxicity of ammonia to Illinois fishes with funding from the U.S. Environ-

Aquatic biologist Keturah Reinbold makes an adjustment on the flow-through system being used to test the toxicity of ammonia to Illinois fishes.

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mental Protection Agency. Ammonia is an important pollutant in Illinois from sewage effluents, feedlot runoff, and urban runoff.

The ammonia toxicity tests are being conducted in a continuous-flow system. Several concentrations of the pollutant are tested simultaneously in a series of test chambers, each of which receives a constant concentration in a continuous flow of water. This is a better method for toxicity testing than has often been used in previous studies in Illinois. Previously the test material and animals have been placed in static water. The flow-through system more closely resembles conditions in a natural stream. Also a constant concentration of the test material is maintained even for volatile substances such as ammonia, which move out of standing water into the air, and for unstable compounds that break down in standing water.

In the Survey study fishes are tested during their early life stages. Since these are usually the most sensitive parts of the fish life cycle, the results are more indicative of the tolerance of the species than are tests with adults, which have most often been done in the past. Four fish species will be tested: green sunfish, white sucker, channel catfish, and walleye. The tests begin with fertilized eggs and continue for 4 weeks after hatching. Effects on egg survival and hatchability as well as on growth and survival of young fishes will be evaluated. The current water quality standards for ammonia are being revised in Illinois and in the Midwest region, and information from this study will be used in the revision of the standards.

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Red-headed Woodpeckers and Acorns

One of the most characteristic sounds of the bottomland forests in winter is the raspy bickering of red-headed woodpeckers defending their food caches. The woodpeckers seemingly chase everything that approaches, from innocuous-looking brown creepers and titmice to squirrels, and from each other. The spectacle of irritated birds flying at one another through the tree tops may be somewhat comical, but it is actually a serious matter of survival. When one sees how hard the birds work to acquire their food stores, the reluctance to share is understandable. A particularly striking example of such work was observed in mid-October 1978 by Jean and Richard Graber in the course of field work in bottomland forest along the Kaskaskia River west of Vernon, Illinois. Several red-heads were collecting and storing acorns from a cluster of three mature pin oaks (*Quercus palustris*) standing about 100 meters from a large block of forest.

Each bird, acting independently, landed in the upper third of a mast tree, picked an acorn, and flew to a storage site in the forest. As many as 12 red-heads could be seen in the air at once. Most were adults, but two were obviously immatures, and the immatures were gleaning acorns exactly as the adults did.

One immature red-head whose entire route could be observed took 41 seconds per round trip from his storage tree, a dead cottonwood (*Populus deltoides*) some 135 meters from the mast trees. Other red-heads had more distant storage sites, but none required more than about 90 seconds to complete a trip. Each bird had its own storage tree. There was no strife between birds at the mast tree, but noisy conflicts occurred whenever any bird came near another's storage site. Apparently acorns at the harvest site are common property, but once gathered they become private property.

From the time required per trip, it was calculated that the 20-25 birds observed were storing 800-1000 acorns per hour. Such intense activity lasted only a few days from the time the acorns became mature until they fell. Ten days later the mast had

Fig. 1. Red-headed woodpecker at nest entrance (Photo by wildlife biologist Dick Graber).

fallen and the birds were no longer visiting the mast trees. From counts made of acorns under the trees and estimates of canopy area, the mast crop that year was about 500,000 acorns per hectare in that site, a very good crop. Jean and Dick Graber reported this incident in a paper in the *Illinois Audubon Bulletin* in the spring of 1979.

Winter red-headed woodpecker populations in southern Illinois show a strong correlation with the importance of the pin oak in forests and with oaks of acorn-bearing size (Graber et al., 1977, INHS Biological Notes No. 102). Moreover there are annual regional fluctuations in numbers of winter red-headed woodpeckers which are probably based to a large extent on the mast crop in the winter range, the center of which for the red-head lies in southern Illinois. The population of winter red-heads in southern Illinois tends to show an alternate-year pattern of highs and lows, and acorn production varies greatly from year to year. This poses an interesting question concerning homing, i.e., the return by an individual bird to the same wintering territory every year. Homing is well developed in birds, but must be very different in a temperate-zone mast feeder such as the red-head. Why home to an uncertain food supply? We will never understand fluctuations in Illinois bird populations until we have consistent, precise annual measurements of their food resources over wide areas. Such understanding is vital to insure that sufficient areas with suitable food plants are provided in order to preserve our wildlife heritage.

Havana Lab Welcomes Electronic Assistant

First, the good news: the Illinois River has been called the most studied river in the world. Illinois Natural History Survey data on its flora and fauna date back to the 1890's. Then, the bad news: a conscientious researcher often has to work full-time for weeks or months just to pick out and tabulate any one aspect of this vast store of biological information. Imagine trying to decipher hundreds of 40-year-old note cards on which the lengths and weights of fish were hastily jotted down.

Now, the *really* good news: the Aquatic Biology Section at the Survey's River Research Laboratory near Havana is using a new Tektronix 4051 intelligent graphics terminal, plotter, and hard-copy unit to organize its river data for a variety of research needs. Aquatic biologist Ken Lubinski is currently teaching the staff how to use the computer to help investigate the river system.

Want to know how many spottail shiners Survey biologists minnow seined from the Illinois between 1957 and 1978? Until recently, you would have had to dig out files for each of the fourteen available years, check for spottail shiner in up to 260 lists of fish for every year (four hauls at each of as many as sixty-five stations), write the numbers down on another sheet of paper, add them up for each year, and divide by the number of hauls. Even a fast worker with a calculator would probably make some mistakes during this tedious procedure — which could eat up four weeks working time.

Havana Lab staff members can now pull the same information out of the computer in five minutes or less — leaving them nineteen days, seven hours, and fifty-five minutes for analysis or field work. All one needs do is put the right tape in the terminal and type in genus and species and the years desired. Buzzing and beeping, the terminal quickly lists the years, reaches of the river, and numbers of spottail shiners taken in each. You can have the list turned into a histogram display, printed on paper by the attached hard-copy unit, or stored for computer plotting as a graph of publishable quality. If you are curious instead about a particular year or area of the river, you can have the data reorganized into a different listing.

Once workers complete the initial labor of correctly punching in the data, the information remains handy for all kinds of uses. Minnow seining, electrofishing, and water quality files for the Illinois River are already accessible.

Fig. 2. *Andrena carlini* on flower of toothwort. This is one of the most important native blueberry pollinators (Photo by Joseph Laury Luth).

Rapid tabulation is only the first step. Yip Tai-sang, survey computer programmer, has written several programs to analyze, sort and display these files. The computer will also make it easier to analyze relationships between two sets of data, such as fish distribution vs. pollutant concentrations or habitat conditions. Of course, the size of the computer's memory limits the volume of data it can process — but a telephone coupler sidesteps this limitation by allowing the Havana terminal to communicate with larger computers when necessary and borrow their larger memory capacities.

This technological revolution could not have come at a better time. As biologists struggle to keep abreast of both voluminous paperwork and fast-changing natural systems, the computer's help in reducing errors and saving time and labor is especially welcome.

Blueberries and Bees

Blueberries are dependent upon native bees for pollination. Without this service, blueberry crops would be nonexistent or inadequate. Honeybees are not good pollinators of blueberries because these plants bloom at a time of year when honeybee colonies are inactive or small and most blueberry crops are grown in northern areas where keeping of honeybees is a marginal enterprise.

The Canadian province of Nova Scotia produces large crops of blueberries. Recent failures of this crop has been attributed to the aerial spraying of insecticides to control spruce budworms and the insecticide (Fenitrothion) used was highly poisonous to native bees. Dr. Peter Kevin, now located at the University of Colorado in Colorado Springs, in cooperation with Survey entomologist W. E. LaBerge has studied the diversity of bees in blueberry fields in Nova Scotia. They have been able to show a decrease in diversity correlated with the use of Fenitrothion and correlated with decreased blueberry yields.

During the six years since Fenitrothion was discontinued in spruce budworm control the diversity of the bee fauna has been carefully monitored. This diversity has been increasing and has about reached the level it was before Fenitrothion was used. Blueberry crop yields have concomitantly increased to normal levels. A report of this project was made to the Sixth International Symposium on Pollination held at the University of Maryland in 1978 and was published in the *Proceedings* of that symposium.

This work is an example of what can be learned with the cooperation of rather distinct disciplines in biology, in this case

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an ecologist and a taxonomist. The thousands of specimens from the study are deposited in the collections of the Survey.

Custom Spray Operators School

The Thirty-Second Custom Spray Operators Training School was held January 8-10, 1980 at the University of Illinois. Opening the three day program were technical meetings of the Illinois Ground Sprayers Association and Aerial Applicators Association. These meetings were held at the Ramada Inn Convention Center in Champaign. Moving to the Illini Union on Wednesday and Thursday, the formal program included speakers from the U of I, Illinois Natural History Survey, and several invited speakers from across the U.S. Attendance at the 1980 School was 1,579.

The goal of the Spray School is to keep custom pesticide applicators and pesticide dealers aware of new developments in all phases of agricultural pesticide use. In addition, a special section of the formal program this year was on scouting techniques for insects, weeds, and plant disease. Delivering the keynote address was Mr. Steven Jellinek, Assistant Administrator of the federal EPA. His topic was on the future direction of federal pesticide regulatory programs.

The Custom Spray Operators School, presented by the Cooperative Extension Service of the University of Illinois and the Illinois Natural History Survey, is considered by many to be the finest school of its type in the nation. During its 32 year history it has kept Illinois agricultural pesticide applicators alert to changing technology and pest management practices.

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Finding Insect Enemies of the Alfalfa Weevil

The alfalfa weevil, *Hypera postica* (Gyllenhal), and the clover root curculio, *Sitona hispidula* (Fabricius), are the most damaging insect pests of alfalfa in the United States. The alfalfa weevil is capable of defoliating an untreated alfalfa field, while the clover root curculio feeds on root nodules, lateral roots, and tap roots. Economic entomologists R. J. Barney, S. J. Roberts, R. D. Pausch, and E. J. Armbrust undertook this study to find specific predators of these two weevil pests and to measure their relative abundance and activity in the alfalfa field.

Pitfall traps were fashioned from galvanized metal guttering cut into 1-meter long sections, and caps were attached at both ends. Clear bathtub caulk was used to seal the traps and prevent leaking.

The linear traps were aligned parallel to a woods bordering the alfalfa field. The traps were sunk into the soil in a staggered pattern of six rows with seven traps in each row. The rows were so aligned that no trap overlapped another trap as they faced the woods. In this manner any mass movement of predators into or out of the woods could be detected.

The 42 pitfalls were partially filled with ethylene glycol to catch and preserve any insect falling into the trap. Every week from 12 September to 15 November the traps were emptied of all insects.

The carabid beetles, *Harpalus pennsylvanicus* DeGeer, *Abacidus permundus* (Say), and *Evarthrus sodalis* LeConte, and a cricket, *Gryllus pennsylvanicus* Burmeister, were the most abundant potential predators found over the 2-month period in the linear pitfall traps. These four species accounted for 94.5 percent of the potential predators caught. Other researchers had found that the most commonly caught carabids are probably the most active and numerous and have the greatest potential for finding and destroying prey that occur on the ground. This 2-month period is also the time of migration by weevils from aestivation sites in the woods back into alfalfa fields. Therefore the weevils are concentrated and susceptible to predation during this field reentry process. The three carabids and the cricket species were also the most frequently caught in conventional pitfall traps in alfalfa in an earlier investigation by economic entomologists R. Cherry and E. J. Armbrust. Cherry and Armbrust recorded the highest catches of predators in September and October, which corresponds to the timing of this study, with the trapping slowing down in November as cold temperatures restricted insect activity.

Live potential predators were collected in a dry pitfall trap. The insects were individually placed in ½-pint cartons containing some litter and covered with organdy. Each of the potential predators was supplied with two weevils, which were replaced when and if eaten. Each individual predator was supplied with only one species of weevil before it was discarded. Five repetitions of each predator with each weevil species were run for 1 week.

All four potential predators tested preyed on both the weevil species. The beetle,

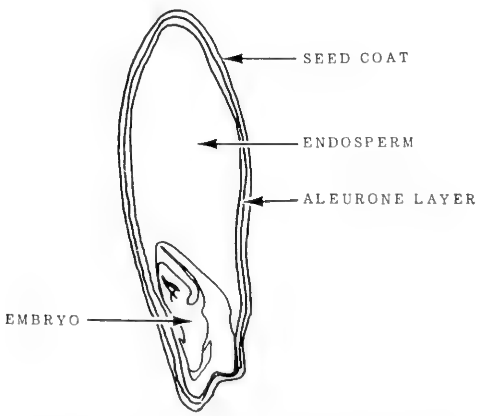
H. pennsylvanicus, and the cricket, *G. pennsylvanicus,* were the most voracious eaters, consuming almost twice as many weevils as the other two.

Cherry and Armbrust found the same four species to be predacious on cocoons of *Bathyplectes curculionis* (Thomson), the primary endoparasite of the alfalfa weevil. Therefore, the four predators many exert more pressure on the beneficial parasite than on the pest. The fact that these general predators feed on both pests and beneficial insects of the alfalfa agroecosystem makes it very difficult to determine their impact on the pest population.

Cellular Control of Seed Dormancy and Germination

A dried-out seed is a "dormant" (literally sleeping) seed. If the dormant seed falls to the ground, it takes up water and resumes its interrupted growth; this process is called germination. Different plant seeds often require different treatments to restart their growth process.

Some seeds, such as lettuce, need light for germination, while others must be exposed to chilling temperatures (a few degrees below freezing) for a few days in a moist condition. Other seeds, for example, winter wheat, do not require chilling for germination, but chilling is required for early flowering. Yet other seeds need stratification; that is, they must be buried in moist soil and maintained for weeks or



A barley seed, showing its various parts. (Drawing by Survey Illustrator Lloyd LeMere.)

even months at moderately low temperature, say about 42°–50° F. The seed coat of others is water impermeable, and germination does not occur until the coat of the seed is weakened. Many of the leguminous trees produce such seeds. It has been reported that the seeds of the East Indian lotus (*Nelumbo nucifera*) have remained ungerminated but viable in the mud of old ponds for several centuries.

Most seeds, however, require only the presence of water for germination. Many agricultural crops, including many cereal grains, belong to this group. The process of germination has been studied in a number of plant species, but probably the best understood is that of the barley seed, since for centuries the beer industry has used germinated barley in the production of malt.

The largest part of a barley seed is its endosperm, which is composed mainly of starchy material and acts as the food reserve. The endosperm is the major constituent of flour. At one end of the endosperm is the embryo, which controls the germination process and uses the endosperm as its source of energy. The endosperm and embryo are surrounded by a cell layer known as the aleurone layer, which plays an important part in the germination process. During the initial uptake of water by the dry dormant seed, the embryo starts its growth process through the release of a plant hormone known as gibberellic acid. The plant hormone diffuses outward and enters the aleurone layer where it induces the formation of enzymes required to convert the starchy endosperm to sugars. The conversion of the water-insoluble starch to water-soluble sugars is a very important sequence, since the embryo of the seed cannot use starch directly to produce the energy required for germination.

The key for proper seed germination is the production of hydrolytic enzymes by the aleurone tissue. Much is known about this important process; but the steps leading to the production of enzymes are poorly understood.

Plant physiologist Claus Grunwald is studying the formation of the endoplasmic reticulum (ER); this is the cellular mem-

brane network responsible for the production of the hydrolytic enzyme. The ER in a dormant barley seed is poorly developed, but once germination begins, this membrane network becomes quite prominent. One of the big questions is whether the cellular constituents needed to form the membranes are present (stored) in the seed or have to be synthesized during the very early stages of germination. This is not an easy question to answer, but it is important in the storage of seeds, not only to preserve a high germination rate, but also in the storage of grain for food purposes. The induction of hydrolytic enzymes during grain storage may greatly decrease the nutritional value of the stored seed.

Illinois Raccoon Populations

Now that pelts of raccoons have increased dramatically in value, especially during the past four seasons — from $1.35 in 1970–1971 to $27.25 in 1978–1979 in Illinois — Illinois and several other midwestern states have suddenly become much interested in the raccoon data that Glen C. Sanderson, Head of the Section of Wildlife Research, has collected for the past 24 seasons. This data has been collected at Perardi Brothers Fur and Wool, Inc., Farmington, Fulton County, Illinois. During the 1978–1979 season, Sanderson made five trips to this fur house and examined 472 raccoons.

The raccoon population in Illinois is at an all-time high despite the dramatic increase in prices paid for raccoon pelts. (Photograph by former Survey Photographer W. E. Clark.)

The low average body weights of young-of-the-year raccoons for the past three seasons are probably explained by high pelt prices that cause previously discarded, very small raccoons to be sold and, thus, weighed. In past years, these pelts were "worthless"; they now bring from $4 to $8 each.

The high percentage of adult females that had not produced offspring observed in 1978–1979 can probably be explained by adverse weather conditions during the breeding season (February) in 1978. For example, in February 1978 the statewide average temperature was 13.5° F below normal compared with 1.7° F below normal in 1977, and the statewide average snowfall was 7.0 inches in February 1978 compared with 3.5 inches in February 1977. These conditions probably restricted movements of raccoons enough so that higher-than-average numbers failed to breed.

If the data collected are indices to major changes in the raccoon population, they do not indicate changes in the population in west-central Illinois. However, these data probably would not reflect a major change in the population until the year after the change occurred. The fact that the raccoon harvest in 1978–1979 increased by nearly 22 percent over that for 1977–1978 suggests that Illinois raccoon populations had not declined as drastically prior to 1978 as many hunters and trappers reported.

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Body weights of raccoons vary as much as 1.5 pounds from one year to the next because of weather conditions but have shown no trends during the past 24 seasons. A decline in average weights of sexually mature fur seals that accompanied a population increase was seen as evidence of competition for food. It seems apparent that the present all-time high raccoon population in Illinois is not having problems finding adequate food.

A charge of groups opposed to the use of the leghold trap is that trappers do not run their traps regularly and leave animals to suffer for prolonged periods. During the 1972–1973 season and from 1974–1975 through 1978–1979, the method of taking raccoons — hunting, trapping, or dead on road (DOR) — was noted. During these years, more than 2,000 raccoons killed by hunters weighed an average of 12.0 lb each, and nearly 600 raccoons killed by trappers weighed 11.6 lb each. A preliminary analysis by age and sex indicates that raccoons taken by trappers did not weigh significantly less than raccoons taken by hunters and killed by cars. Thus, Illinois raccoon trappers run their traps often enough so that trapped raccoons do not lose significant amounts of body weight; however, no attempt has been made to determine the length of time required for steel-trapped raccoons to lose a significant amount of weight.

From 1972–1973, when raccoon pelts were worth an average of $5.37 each in Illinois, to 1978–1979, when they were worth $27.25 each, the percentages of raccoons taken by hunters, trappers, and DOR have changed. In 1972–1973 the percentages were 70.9 killed by hunters, 28.0 taken by trappers, and 1.0 DOR. In 1978–1979 the percentages were 78.6 for hunters, 19.6 for trappers, and 1.7 for DOR. Thus, it appears that increased pelt values have resulted in relatively more hunting pressure rather than trapping pressure on raccoons in Illinois.

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Hop Vine Borer in Corn

Several caterpillars, including the European corn borer, black cutworm, common stalk borer, and armyworm, appear almost perennially in Illinois corn and are dealt with rather routinely by growers and entomologists. Other catepillars are more sporadic in their appearance and may cause minor to major yield losses in isolated areas. These sporadic pests occasionally are difficult to identify because of the scarcity of information about them. The hop vine borer, *Hydraecia immanis,* a caterpillar of the family Noctuidae, is a recent example of such an insect.

The hop vine borer feeds in the bases of corn plants during May and June, usually killing the plants in the process. It has become a problem to corn growers in the contiguous areas of Illinois, Iowa, Minnesota, and Wisconsin. Multiple reports of its damage to corn in the Midwest can be traced to the mid-1970's. The Illinois counties in which it has been detected in corn include Boone, Carroll, DeKalb, Ogle, Stark, Stephenson, and Winnebago. The species also has been reported from New York.

The identity of the species became confused when a related species, the potato stem borer (*Hydraecia micacea*), was detected by entomologists in New York in 1975. This species is an Old World caterpillar that inadvertently was introduced into Canada during the late 1890's. It was confined for 75-80 years to the extreme northeastern United States and the eastern maritime provinces of Canada. Its verified appearance in New York was coupled with a nearly simultaneous report of its occurrence in Wisconsin and of a possible third species in Minnesota. The Wisconsin and Minnesota reports were based on tentative examinations of the larval stages of the involved species.

It became apparent that any pest management programs being planned for *Hydraecia* in Illinois and surrounding areas would be greatly aided if the exact number of species involved were known and if their larvae could be easily recognized. Survey entomologist, George L. Godfrey, in cooperation with other entomologists at the Survey, Cornell University, Iowa State University, University of Minnesota, University of Wisconsin, and the

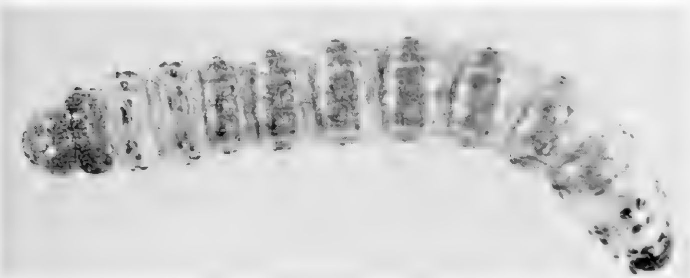

Fig. 1. Fully grown larva of the hop vine borer, *Hydraecia immanis* (Photo by G. L. Godfrey).

Canadian National Collection began a systematic study to clarify the situation.

The efforts established that the hop vine borer is the only *Hydraecia* species presently attacking corn in the Midwest. The confirming evidence will soon appear as a paper by Godfrey in a INHS *Biological Notes*. However, it is reasonable to assume that the potato stem borer, the introduced species, will someday appear in Illinois. The descriptions and illustration in Godfrey's forthcoming publication will help promote its detection if the event occurs.

IPM — New Employment Opportunities in Illinois

Pest scouting is an important tactic in integrated pest management (IPM) and it is currently the most visible activity in IPM. It is providing seasonal and full-time employment for a growing number of people. Pest management consultants, including pest scouts who offer their services for a fee, is a new industry in Illinois. It is an excellent example of a new program begun in the public sector eight years ago, but which is now being adopted by the private sector.

Eight years ago there were no pest management consultants and pest scouts in Illinois. Today there are 18 firms employing 21 full-time pest management consultants and approximately 130 seasonal employees. They are serving slightly over 1200 grower-customers in 86 counties in Illinois. The research and education to support this new industry is supplied by scientists and extension specialists in the Illinois Natural History Survey and the University of Illinois. Research is needed to provide new information and to continually upgrade existing IPM technology. Educational programs transfer this information and technology to the user. The Sixth Crop Protection Workshop for pest management consultants and scouts was held March 11, 12, and 13. The Workshop attracted 372 participants in 1980; 102 more than in 1979. The evening training sessions gave participants the opportunity to identify weeds, insects, and diseases, and to study the application of programmable calculators to pest detection and decision making. The Field Crop Scout Training Program was offered for the 3rd year on April 2-4, 1980. To support these on-campus workshops and schools, four multi-county training sessions will be held in the field during the 1980 crop growing season. These will provide real-world experience for permanent and seasonal employees in IPM. Information on the date, time, and location of these field training sessions can be obtained by writing extension entomologist Donald Kuhlman, IPM Coordinator, 172 Natural Resources Building, Illinois Natural History Survey, Urbana, Illinois 61801.

Illinois growers have developed much interest in integrated pest management and with acreage scouted increasing each year, there is a continuing need for more trained scouts. The major emphasis to date has been on the detection and management of pests in corn and soybeans, but this will undoubtedly expand in the future to include other crops.

Daily Aging of Fish

The age of fish has been determined by counting the annular marks in their bony parts (scales, vertebrae, opercular bones, spines, otoliths, etc.) or by conducting extensive experiments on marking and recapturing of fish. Although the age of fish in years is extremely important to fishery biologists, they have been unable to determine the age of fish from tropical climates (annular marks absent), fish under one year, or fish from disturbed environments such as cooling reservoirs where hot water hinders the production of annular marks. Recently, fisheries biologists have determined that the inner ear bones (organs of equilibrium called otoliths) are composed of layer upon layer of daily rings. These layers have been used to determine daily age of fish and to aid in elucidating life history information such as dates of spawning, growing season, and the effects of environmental conditions on growth rates.

Survey aquatic biologist Bruce D. Taubert studied daily rings in otoliths of fish from North and South America and Africa and has published papers on the technique used to reveal daily rings and the validity

Fig. 2. Frontal section of an otolith from a pumpkinseed sunfish (*Lepomis gibbosus*) showing daily rings (Photo by Bruce D. Taubert).

of daily rings. In general, most fresh water fish produce the first daily ring in their otolith at the time of yok-sac absorption or swim-up. From then on a daily diary is kept in the otolith showing daily growth, changes in growth rates, and cessation of growth. In young fish the determination of daily age is accurate but as the fish grows older events take place that hinder analysis of daily age. Normally, fish stop growing when they spawn, overwinter in temperate climates, or become very old. These events are recorded in the otoliths because daily ring production stops when growth stops.

To reveal the record of daily and seasonal growth in otoliths is as easy as sectioning a rock to look at its inner structure and much of the equipment and methods used in sectioning otoliths was developed by lapidaryists. After removal from the fish an otolith is secured to a glass microscope slide with a drop of lakeside balsam. In small fish this is all of the preparation necessary and the daily rings can be counted with the aid of a microscope. In young, small fish otoliths are about the size of the eye of a sewing needle. In older and larger fish the otoliths become irregularly shaped and thickened and in order to reveal the daily rings the otolith must be sectioned. The otolith is ground against carborundum paper until a thin section through the center of growth or nucleus is produced, then polished and the rings counted.

In Illinois, Survey biologists are using otoliths to determine basic life history data of fish from Lake Sangchris, Lake Coffeen, and Lake Shelbyville. In Lake Sangchris Survey aquatic biologists Bruce D. Taubert and John A. Tranquilli have used otoliths to reveal life history information about threadfin shad (*Dorosoma petenense*) and largemouth bass (*Micropterus salmoides*). Survey aquatic biologist Ted Stork working on Lake Shelbyville will be using daily rings to determine time of spawning for all species present, and Survey aquatic biologists Lanse Perry and Dennis Newman will be using otoliths to determine previously unavailable information on differences in spawning dates and growth rates of largemouth bass from hot water and ambient areas of Lake Coffeen. These tasks can be accomplished by the otolith method at great savings in time, effort, and equipment.

Cottontails and Grassland

Natural regulation of the abundance of cottontail rabbits is effected through a complex of interacting mechanisms that relate to environmental conditions and events. Trends in statewide abundance reflect the general pattern of events occurring throughout Illinois. Trends in the abundance of local populations can and do differ from the average statewide trends.

Studies of the population dynamics of cottontails conducted since the mid-1950's by Survey ecologist William R. Edwards demonstrate changing patterns of agricultural landuse to be closely associated with changes in cottontail abundance in Illinois. Over the past 25 years the average abundance of cottontails has declined at least 70% statewide, and 90 to 95% throughout most of the intensively farmed central and east-central counties. Roughly 80-85% of

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the decline in cottontails was associated with the pattern of increased production of row crops, decreased acreages of hay, oats and pasture, larger farm and field sizes, and increased use of herbicides and pesticides. The primary constraints on wildlife abundance clearly relate to land-use phenomena that determine base levels of carrying capacity. Prevailing weather conditions are responsible for short term fluctuations about these base levels.

Cottontails on the 4-H Area at Allerton Park have not evidenced the long-term decline demonstrated by the general statewide pattern of abundance. At Allerton, rabbits were abundant in the late 1950's, scarce in the early 1960's, reached a peak again in 1976, and have declined markedly since. The high in 1976 is considered to reflect unusually good survival related to favorable weather. Numbers present in 1977 indicated average abundance and survival in terms of numbers although the percent survival was down relative to the high population in 1976. Survival was low during the winters of 1977-78 and 1978-79 and was attributed to severe weather, particularly prolonged periods of deep snow and sub-freezing temperatures.

The reproductive capacity of the cottontail has long been known. Adult females may produce 4-5 litters each year, and early born young may produce one or even two litters their first summer. There is no evidence that the statewide decline of cottontails is related to a pattern of reduced reproduction. Predation is recognized as a primary cause of mortality but its effect on a population depends on the security offered by the habitat. Where landuse does not supply an abundance of secure niches, cottontails are not numerous. On a short term basis, severe weather makes habitats relatively less secure.

On a statewide basis we can expect to see a continuing pattern of changing cottontail abundance. We should see some weather related, short term and local population increases, but the basic long term decline in cottontail populations in Illinois will continue unless there is a trend toward less intensive agriculture. The world's need for food, our national need for export commodities, and the current energy related move to grain alcohol as a fuel, preclude any trend to less intensive agriculture.

It is important that losses of grassland habitats be viewed in much the same way as we are beginning to appreciate the destruction of forest and aquatic habitats. Conservationists and wildlife managers should strive to develop and preserve grassland habitat where possible on public and private lands. The true plight of grassland animals such as the cottontail is only beginning to be appreciated.

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Swine Manure and Grass Carp in Bass Ponds

Preliminary findings indicate that moderate enrichment of fish ponds with swine manure and control of pond weeds by grass carp are beneficial to the growth of bass in their first year of life. So say Survey aquatic biologists Homer Buck and Dick Baur after the first year of a three-year study at the Sam Parr Fisheries Research Center, a field station of the Illinois Natural History Survey near Kinmundy.

The swine manure is used as a fertilizer to increase the production of fish foods. The Chinese grass carp is used to reduce excessive growths of pond weeds. However, the grass carp is believed to serve a double function. The Chinese say, "If you feed one grass carp well, you feed three other fishes." They believe this saying because the grass carp consumes such massive quantities of vegetation that it serves as a swimming manure factory. Thus, the pond is enriched in two ways, by the swine manure and by the carp manure.

Such organic enrichment yields dividends not provided by inorganic chemicals. In addition to promoting the growth of phytoplankton, it stimulates the production of heterotrophic bacteria. This production of bacteria initiates a wave of production through the entire food web, from bacteria to protozoa to zooplankton to benthos, that inevitably must benefit the fishes, both prey and predator species.

This research is a companion study to a separate investigation of the largemouth X smallmouth bass hybrid, the so-called meanmouth bass. While it involves both pure largemouth bass and hybrids, no comparisons between the largemouth and the hybrid are being made at this time.

The experimental design involved six one-acre ponds, all of which were stocked with equal numbers of both largemouth and hybrid bass fry and with bluegills and fathead minnows to provide forage for the growing bass. Four of the six ponds each received the wastes from ten fattening pigs distributed as a slurry twice weekly, and two of the four ponds also were stocked with grass carp. The remaining two ponds received neither swine manure nor grass carp and served as controls.

All ponds were drained and censused following a 130-day bass growing season. The average fall standing crops of bass (both largemouth and hybrids) were 119 pounds per acre in the ponds which received both swine manure and grass carp, 84 pounds per acre in those which received only swine manure, and 80 pounds per acre in the control ponds.

To Freeze or Not to Freeze . . .

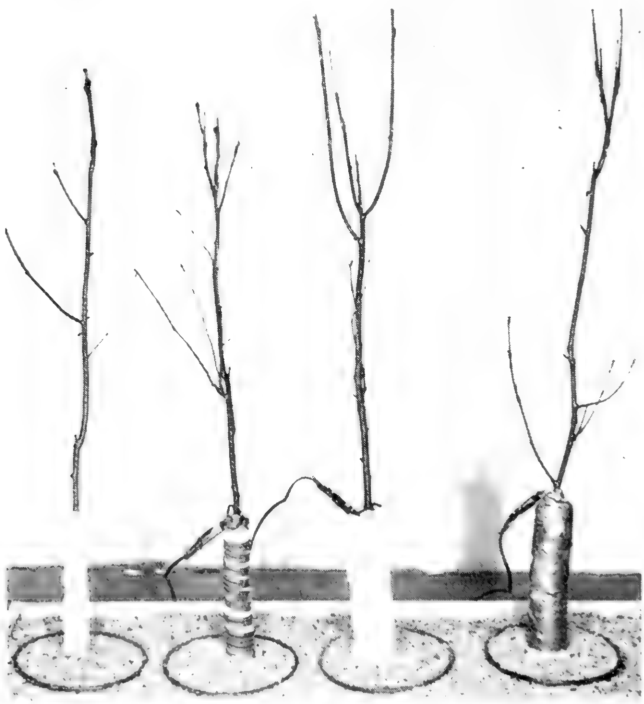
Midwest winters are warm or cold, long or short, wet or dry. Above all, they are highly unpredictable. As climatic conditions vary from year to year, the stresses imposed on trees and shrubs by winter weather also vary. Some species show damage nearly every year, while others are rarely affected.

Woody plants that survive many winters in Illinois must acclimate to temperatures below zero. If they are not acclimated at

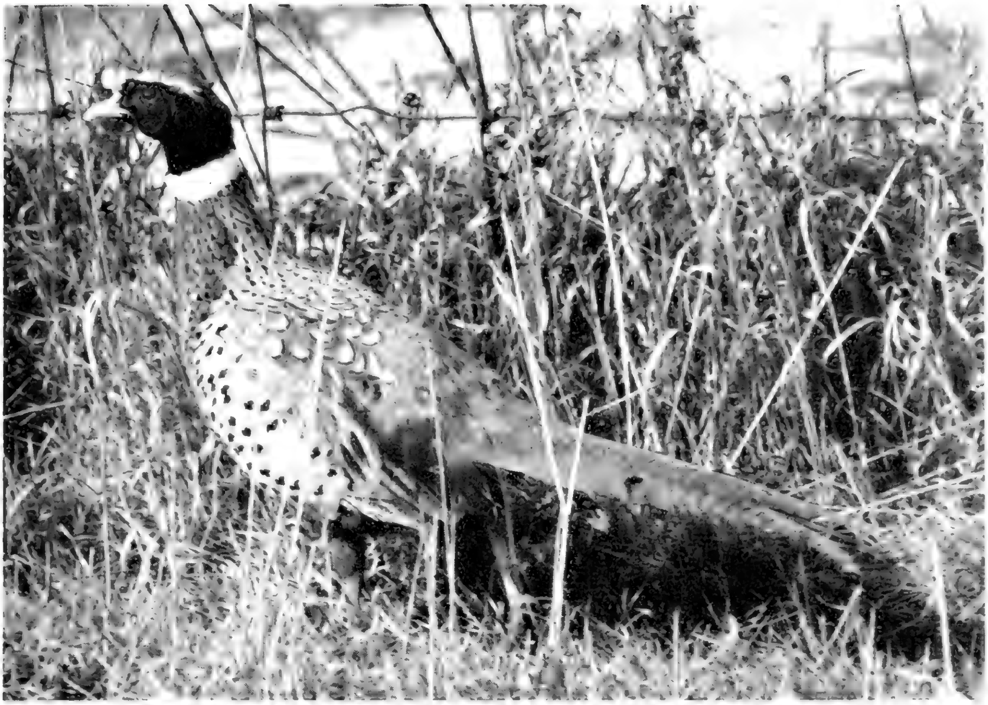
the time a hard freeze occurs, they may suffer from freezing stress. Severe stress causes bud kill, frost collars and cracks, and stem dieback. Less severe stress may weaken plant tissues without actually killing them and result in increased susceptibility to attack by disease organisms. Stem canker and dieback diseases are often associated with freezing stress.

Many studies have been conducted on hardiness to freezing injury in woody plants, but until recently little was known about how freezing affects susceptibility to disease. Information was lacking on the level and duration of freezing required to alter disease susceptibility and whether freezing stress on one portion of a plant would cause other portions to become susceptible. To answer these questions, Survey plant pathologists D. F. Schoeneweiss and E. G. Wene devised a method for differentially freezing whole plant stems under controlled conditions. Portions of stems were wrapped with insulation and heating cables, and those stem parts were maintained above freezing, while adjacent exposed portions were frozen (see photo). When frozen and unfrozen stem portions were inoculated with canker fungi, only those portions subjected to temperatures below zero became susceptible to attack. The fungi were not able to grow into the portions protected against freezing stress.

Apparently freezing stress in woody stems is localized; that is, only stem tissues subjected to freezing temperatures below a critical degree become susceptible to attack by canker fungi. Portions of stems protected by snow cover or mulch may survive hard freezes and not become targets for disease organisms. Since protected stems remain resistant to disease, pruning out portions with canker and dieback symptoms is recommended as a control measure. The remaining plant will usually put out new growth and recover from damage caused by stress-related pathogens. In addition, plants that acclimate quickly in the fall are less likely to be stressed by freezing. Therefore, late season pruning and fertilizing, which delay acclimation, should be avoided.



Portions of tree stems insulated to allow differential freezing (Photo by D. F. Schoeneweiss).



Pheasants in Illinois have traditionally been most abundant in the east-central counties (Photo by L. M. David, Illinois Department of Conservation).

Fall Land Use and the Survival of Pheasants

The relative abundance of ring-necked pheasants in east-central Illinois is primarily related to agricultural land use. Research on the Sibley Study Area (SSA) has shown the importance of forage legumes and small grains (particularly oats) for successful nesting and brood rearing by pheasants.

However, relatively little work has been directed toward the relationship of fall land use and the survival of pheasants during the cold season. Trapping and marking studies on the SSA from 1962 through 1965 indicated that the death rate of pheasants, October to February, averaged 75 percent of the early fall population; only 25 percent of these deaths were attributed to hunting. Although survival rates may have been less than average for 1962–1965, these findings illustrate that mortality of pheasants is perhaps greatest during fall and early winter.

Wildlife biologist Richard E. Warner recently completed a statistical analysis of the relationship between fall land use characteristics and the survival of pheasants through late winter on the SSA from 1960 through 1970. The three components of fall land use that were considered in the analysis were acreages of unplowed hay and small grains, unplowed row crop stubble (primarily corn), and plowed farmland.

During the 1960's the amount of land planted to hay and oats declined with the expanded production of corn and soybeans. Fall plowing varied among years in conjunction with weather conditions. Numbers of pheasants on the SSA peaked in the early 1960's, declined substantially from 1963 through 1965, and were relatively stable from 1966 to 1970.

A significant positive relationship was found between acreages of unplowed hay and small grains and densities of pheasants on the SSA in late winter to early spring. However, the correlations do not account for how land use and the reproduction of

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pheasants during the growing season may interact with fall land use and numbers of pheasants that survive through late winter. Thus, correlations of fall land use characteristics with late winter pheasant populations may be primarily a reflection of the importance of a particular cover type to the recruitment of pheasants during the reproductive season.

The correlation coefficients resulting from another analysis suggest that (1) the characteristics of fall land use that were considered in the analysis do not directly explain variations in the number of pheasants that survived on the SSA through late winter, and (2) the significant correlation of the acres of unplowed hay and small grains with late winter densities of pheasants primarily reflects the amounts of hay and oats present during nesting and brood rearing and subsequent recruitment to the fall population.

Although fall land use could not be directly linked to pheasant survival in this analysis, there is little doubt that more subtle — thus far unmeasured — characteristics of fall land use affect rates of pheasant survival on a year-to-year basis.

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Prairie and Prairie Chickens

Practically all tillable portions of the 1,641 acres now in prairie chicken sanctuaries in Illinois had been cultivated annually for over a century prior to acquisition. The one exception, the Walter's 40-acre tract in Jasper County (unplowed since the mid-1950's), is today covered 75% by native prairie vegetation and 25% by woodland. Three prescribed burns (1974, 1976, and 1979) by wildlife biologist R. L. Westemeier and his assistants have apparently hastened the spread of prairie plants over the Walter's tract. This tract now contains one of the best stands of little bluestem (*Andropogon scoparius*) to be found in the south central counties.

Seeded native prairie grasses, mostly switchgrass (*Panicum virgatum*), Indiangrass (*Sorghastrum nutans*), and big bluestem (*Andropogon gerardi*), are now predominant species on about 157 acres of the 1,001 acres of prairie chicken sanctuaries in Jasper County. Prairie grasses are also started, though not dominant, on another 29 acres. An additional 143 acres are tentatively scheduled for establishment of prairie on erodable slopes, waterways, or fields that are not well suited to periodic cropping. Thus, the cover on at least 358 acres (over one-third of the sanctuaries) at Bogota will eventually involve restoration of prairie vegetation.

Although the young stands of native prairie grasses were shown in previous reports to be among the poorest cover for nesting prairie chickens with regard to density of hatched nests and percentage success, there are indications that this situation is changing. Nest success in prairie grasses has increased steadily from 25% in 1972 to 75% in 1979 except in 1978 when

Male prairie chicken (Photo by former Survey photographer, W. D. Zehr).

success dropped to 33%. In 1979, the three hatched nests found on the Yeatter Sanctuary were all in fields dominated by prairie grasses. In 1979, prairie grass predominated around the bowls of all of the five nests found in fields where prairie grasses were present. From 1966 to 1978, prairie grass predominated around the nest bowls of only 64% of the nests found in fields with prairie grass.

The increased use of and success in prairie grass by chickens may be due to gradual maturity of stand and improvement in the quality of prairie grass stands. Type of management also appears to be a key factor. Nest densities and nest success were compared in four categories of prairie management: (1) no disturbance, or mowing for (2) weed control (mw), seed (ms), or nesting enhancement (mn), (3) haying, and (4) prescribed burn. Although data for all categories are still limited, results for the mowing category (ms, ms, and mn) compare favorably with nonprairie grass areas. Nest density (nests per 10 acres) and nest success were 2.2 and 50.0% respectively. By contrast, comparable figures for the undisturbed, hayed, and fresh burn categories were 0.9, and 27.3%; 0.4, and 25%; and 0.0, and 0%; respectively.

This is encouraging as prairie restoration seems axiomatic for prairie chickens; however, more data are necessary to confirm the indicated relationship. It would be desirable to try limited grazing with the other approaches to prairie management.

The prairie chicken project is a cooperative project between the Survey and the Department of Conservation, using Pittman-Robertson funds.

The Kankakee River

The Kankakee River, considered to be one of the finest rivers in Illinois, originates near South Bend, Indiana, flows westward into Illinois and joins the Des Plaines River to form the Illinois River. During early settlement of the Kankakee Basin the river was channelized in Indiana to increase flow and facilitate drainage of the land. Modification of the river in Indiana resulted in a fast-flowing ditch that slows markedly when it reaches the more natural, meandering river at the Illinois border. Concern exists among Illinois citizens that sediments washed into the Kankakee River in Indiana are deposited as they reach the slower moving Illinois portion of the river, and that these deposits are reducing the diversity and abundance of aquatic life.

Because of this concern, the Illinois Institute of Natural Resources is funding a study by the State's three Scientific Surveys on the effects of sedimentation in the Illinois portion of the Kankakee River. The Natural History Survey is examining the effects of sedimentation on selected groups of aquatic organisms; emphasis is being placed on fishes, mussels, midges, aquatic beetles, and caddisflies. Information obtained is being compared to available historical data and the present and probable future effects of sedimentation in the river are being evaluated.

The diversity of fishes in the Kankakee River is higher than in most Illinois rivers, and because of improved collecting techniques, is higher now than was indicated in previous studies of the river. Several extremely rare species, most notably the northern brook lamprey, pallid shiner, and river redhorse, still are found in the river.

In contrast to the fishes, mussels have undergone a drastic reduction in diversity and abundance in the Kankakee River over the past 70 years. Increased sedimentation probably contributes significantly to the reduction, although pollution, overharvesting, and habitat modifications other than sedimentation also are suspected of causing declines in mussel populations.

Data on insects are still being analyzed but the high diversity of aquatic beetles and caddisflies indicate that, as with fishes, the Kankakee River is in better condition than are most rivers in Illinois. The Kankakee River supports nearly a third more species of water beetles than does any comparably sized watershed in Illinois. A dozen species of caddisflies are known in Illinois only from the Kankakee River.

Sedimentation in the Kankakee River is a problem and needs to be monitored to prevent further degradation of the river. Among the organisms studied, mussels appear to be the most sensitive to sedimen-

tation, and they may be ideal organisms to study throughout Illinois to determine the environmental conditions of our rivers.

Hybrid Carp and Aquatic Weeds

As a natural course of events, lakes, ponds and often large reservoirs become heavily infested during warm weather with unsightly growths of aquatic weeds and algae, which ultimately may make waters unsuitable for fishing, swimming, irrigation, or other uses. Aquatic scientists have considered three basic techniques for the removal of nuisance vegetation: chemical herbicides, mechanical harvesters, and various forms of biological control.

The application of chemical herbicides probably has been the most effective and widely used short-term alternative but, since fossil fuels are used in their manufacture, the use of aquatic herbicides are becoming cost prohibitive. In addition, aquatic scientists are uncertain and fearful of specific after-effects of various chemicals on non-target species (both plant and animal). Although considerable work and research has been conducted on mechanical harvesters for aquatic plants, this type of control is also proving costly, and it has not been sufficiently developed for use in certain types of habitats, such as small ponds.

In view of the disadvantages of chemical and mechanical control strategies, the potential for a certain biological agent appears to be very promising. In recent months, the grass carp or white amur (*Ctenopharyngodon idella*) has received a great deal of attention.

Presently the introduction or use of the white amur is illegal in 32 states, including Illinois, due primarily to the paucity of information regarding the fish's natural history, ecology, and its potential impact on wetlands utilized by waterfowl and naturally occurring fish species. Fortunately, recent genetic research in Hungary and the Soviet Union has produced a reportedly sterile carp hybrid which retains the feeding characteristics of the grass carp. That these new fish are incapable of reproducing provides some interesting ramifications for aquatic weed control.

Hybrid grass carp or white amur (Photo by Survey aquatic biologist, Homer Buck).

The opportunity to investigate the efficacy of the hybrid carp as a biological weed control agent for aquatic systems is now at hand for a large multidisciplinary team of aquatic scientists at the Illinois Natural History Survey. The research strategy is designed to compare the hybrid carp and chemical methods as effective means of controlling aquatic vegetation. Following one preliminary year of obtaining baseline data and perfecting methodologies, the team will define a 3-year experimental period of specific effects of the two approaches on the microbial, plankton, benthos, and aquatic plant communities, and on the sport fishery. The study continues one step further by assessing pertinent water physics and chemistry parameters and by determining the functional processes of plant decomposition, the cycling of important nutrients, and the flow of energy moving into and from each component group of the ecosystem. Data gathered from these studies will provide a basis for predictive management practices for both the sport fishery and the hybrid carp. This 4-year project is being supported by Dingell-Johnson funds allocated from the U.S. Fish and Wildlife Service through the Illinois Department of Conservation.

Corn Rootworm Egg Sampling

The northern corn rootworm, *Diabrotica longicornis* (Say), is a pest of corn with the larvae attacking roots and the adults feeding on pollen, silks, and leaves. There is only one generation/year and eggs are laid in the soil during August and September.

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The two practical methods of predicting infestations are sampling for adults and for eggs. There are at least four reasons that sampling for eggs would be advantageous over sampling for adults: the egg stage immediately precedes the stage that causes the most important damage; eggs are stationary; eggs are in the field and available for sampling for an extended period of time (September to May); and sampling for eggs is not affected by time of day, weather conditions, or plant maturity.

Survey entomologists W. G. Ruesink and W. H. Luckmann and research assistant R. E. Foster recently studied the spatial distribution of rootworm eggs and compared five methods of sampling. The maximum depth at which eggs occur was not established since they continued to find them in the deepest samples, but 85% of those found in the upper 20 cm were located in the top 10 cm. Northern corn rootworms show a high degree of preference for oviposition at the plant base, while in the row between plants is of intermediate preference, and the area between rows is least preferred.

Of the five sampling methods only two proved to be reliable. The core method used a sampler similar to a bulb setter. A sample consisted of ten cylindrical cores, 5.4 cm diam and 10 cm deep. These ten cores were sifted through a screen, mixed, and a standard subsample was removed for processing. These samples consisted of plant-base samples (immediately adjacent to the corn stalks) and between-row samples (midway between two rows of corn).

For the frame method all soil was removed from a trench perpendicular to the row and exactly the row width long. To make this task easier, a metal frame 10 cm deep x 10 cm wide x one m long was constructed. This frame was pushed into the ground at the desired location, and all the soil within the frame as long as the row width was removed with a trowel. All soil taken from within the frame was thoroughly mixed, and the standard subsample was removed for processing.

For any sampling program, one of the important questions is how many samples to take. These two methods produce nearly identical levels of reliability for an equal number of samples, but the frame method requires about a third more time. On the other hand, the core method depends on some assumptions about spatial distribution that the frame method does not. Thus the normal core method would be best if the emphasis were on time, and the frame method would be best whenever a high degree of accuracy is desired.

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Weevil Released to Control Musk Thistle

The musk thistle is a prickly, bristly weed that grows in large patches in Illinois fields, permanent pastures, and strip mine areas converted to pastures. In June 1979, Illinois Department of Agriculture personnel released about 1,200 adult specimens of the musk thistle weevil, *Rhinocyllus conicus*, at six locations in our state. The collection, release, and monitoring of the weevils was a joint effort of the Illinois Department of Agriculture, the University of Illinois Department of Agronomy, and the Illinois Natural History Survey.

The purpose of these insect releases was to determine whether this weevil could establish permanent populations in Illinois and provide biological control of the musk thistle here. The larvae of this weevil eat the seeds of the musk thistle and thus restrict the plant's reproduction. The adults do a relatively small amount of damage by feeding on the thistle leaves.

About 200 weevils were released at each of six sites near Shawneetown, Gallatin County; Ware, Union County; Edwardsville, Madison County; Cuba, Fulton County; Aledo, Mercer County; and Mor-

The musk thistle weevil, *Rhinocyllus conicus*, on a bull thistle leaf in the laboratory. Photo by James Appleby.

Bill Lewis, Illinois Department of Agriculture, examining a musk thistle for weevil eggs. Photo by Clarence White.

aine Hills State Park, McHenry County. Natural History Survey Economic Entomologist Clarence White has been cooperating with Department of Agriculture personnel by monitoring weevil establishment in the field.

Between May 28 and June 17, 1980, Entomologist White visited each release site with the person who had made the release. Their purpose was to determine how successfully the weevils had overwintered and the extent of their dispersion and egg laying in the spring. At each site a 10-plant sample was inspected for egg masses and adults. They also inspected thistles around the release site to determine how far the weevils had dispersed.

They observed egg masses and adult weevils at five of the six release sites. Thistle plants in their samples had 0-19 egg masses on them, and the averages from the five sites were 4.7-8.3 egg masses per plant. Adult weevils were observed at the release sites and at distances of from ⅛ to ¾ of a mile from the sites.

Only at the Gallatin County site did the researchers find no egg masses or weevils. At that site a herbicide had been used in 1979. Apparently, the weevils' food supply had been eradicated, and no weevils had survived there.

Entomologist White concludes that, with the exception of those released at the Gallatin County site, the weevils overwintered well, dispersed well in the spring and laid many eggs, and are now well established in Illinois. However, White notes that, if our experience is similar to that of western states, the weevils will disperse widely during the next 4-5 years before populations develop that are large enough to exert any important control on the musk thistle.

White-Tailed Deer in East-Central Illinois

White-tailed deer have become abundant in Illinois since their reintroduction in the late 1930's. Harvests of nearly 20,000 deer by 60,000 hunters have occurred in each of the past 2 years. Little is known about the characteristics of deer habitat. To determine these characteristics and to determine how much deer range remains in Illinois and where it occurs, Survey Wildlife Biologists Charles Nixon and Lonnie Hansen and Research Assistant James Chelsvig have begun a cooperative research project with the Department of Conservation dealing with deer ecology and management in Illinois.

Even though winter in Illinois is usually relatively mild, it is a period of stress. The absence of woody cover limits the winter distribution of deer in Illinois, particularly in the central, east-central, and northern counties.

In these counties it has long been known that deer tend to concentrate in localized habitats in winter. In the Rock River watershed, for example, deer moved 10 miles or more to areas along the river in late fall and remained until late March or April, when they returned to their summer range. If such concentrations of deer are found each winter and if the same areas are used each winter, the identification and description of these areas would be of great value in managing Illinois deer.

One area that appears to hold a large winter deer population is Robert Allerton Park in Piatt County. Survey biologists captured 21 deer there in late winter and spring 1980. The deer were captured with a 40- X 50-foot nylon net propelled by rockets, which carry the net over the deer as they feed at a bait pile of corn, apples, and block salt. Most of the deer were marked with collars or ear streamers. Five does were fitted with collars containing small radio transmitters, enabling the biologists to follow the deer and to determine the types of cover deer use at different times of the day.

Minimum seasonal home ranges were calculated for the radio-monitored deer, and they range from 275 to 500 acres during winter and from 75 to 210 acres during summer. During winter, deer were primarily found in dense brushy areas in timber during the day and in wheat or alfalfa fields at night. In the summer, deer make extensive use of cornfields during both day and night. It is believed that part of the reason for using cornfields, aside from their providing good cover, is to escape from the biting insects that are so common in woods.

A fawn captured and marked after biologists located her radio-collared mother. Photo by James Chelsvig.

The distances between winter and summer ranges have been surprising. The radio-monitored deer have moved 4.5-38.0 miles between winter and summer ranges. One yearling buck was seen a mile north of Taylorville, 48.5 miles from where he was marked.

The effects of intensified farming on small game populations, particularly pheasants and rabbits, have received much attention, but there has been less concern about the effects of increased row cropping, fall plowing, and more efficient combines on the availability of deer foods. Corn and soybeans are important fall, winter, and spring foods for deer from central Ohio west to the Great Plains. These high-energy foods are needed for deer to combat harsh winters, when cover is scarce and protection from the weather is limited.

The intensive land use prevalent in Illinois forces deer to adjust their activities to constant disturbance. Understanding how they do this will help the Department of Conservation do a better job of managing Illinois' only big game animal, the white-tailed deer.

New Survey Field Laboratory on Largest U.S. River

The Mississippi River will receive close scrutiny from Illinois Natural History Survey biologists and other scientists during the next 2½ years in a research program tied to the controversial issue of whether a second lock should be built at the new Alton Lock and Dam.

Drs. Kenneth S. Lubinski and H. H. Seagle of the Survey's Aquatic Biology Section will supervise these studies from the Survey's newest field laboratory at Grafton, Illinois, where the Illinois and Mississippi rivers flow together. Appropriately located on the riverfront, the laboratory's two buildings are leased from the Illinois Department of Conservation.

Cooperating with the Natural History Survey in the venture are scientists from the Illinois State Water Survey, Illinois State Geological Survey, and Western Illinois University. Dr. Richard E. Sparks of the Aquatic Biology Section will coordinate the work at Grafton with studies being conducted by five other agencies upstream on the Mississippi near La Crosse, Wisconsin.

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Biologists and hydrologists will join forces at the Grafton Lab to study ways in which barge and pleasure boat traffic affects the Mississippi and the aquatic creatures that call it home. Congress has authorized the Upper Mississippi River Basin Commission to fund this study as part of the 1978 compromise that allowed the construction of one replacement lock for barge traffic at Lock and Dam 26 near Alton. Under this law, the decision on whether to add a second lock — thus increasing barge traffic on the river — must wait until a $12 million Master Management Plan for the river is completed. The plan includes both economic and environmental analyses.

The budget for the research at Grafton is just over half a million dollars. Substantial amounts of state and federal tax money already go to government agencies responsible for the upper Mississippi River: the Fish and Wildlife Service maintains refuges for fish and wildlife; federal and state environmental protection agencies maintain and upgrade water quality; and the U.S. Army Corps of Engineers develops structures for navigation and flood control.

Do these agencies — all working for the same taxpayers — sometimes pull in opposite directions, perhaps without knowing it? For instance, a second lock at Alton *might* increase barge traffic enough that river-bottom sediment would be stirred up in amounts exceeding water quality standards, and these sediments in turn might settle out in a wildlife sanctuary. In such a hypothetical situation, the tax dollars used to improve navigation might then require *more* tax dollars to be spent to undo the effects of the increased barge traffic. It makes sense to spend some money to make sure that each agency can accomplish its work on the Mississippi River without interfering with the work of others.

Once the Grafton project and other studies are finished, the Upper Mississippi River Basin Commission will use the results to decide whether there are any such conflicts, and if so, how to resolve them.

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George Sprugel, Jr., Retires
Search Underway for New Chief

Dr. George Sprugel, Jr., retired August 31 after 14 years as Chief of the Natural History Survey. Some of the major accomplishments during his tenure were the building and instrumentation of the Natural Resources Annex on the University of Illinois, Urbana-Champaign campus, the development of an extensive grant and contract program, and the expansion of eight field stations in various locations around the state.

Dr. George Sprugel, Jr., Survey Chief, 1966-1980 (Photo by Larry Farlow, former Survey Photographer).

Sprugel came to the Survey in 1966 from the National Park Service in Washington, D.C., where he was Chief of the Division of Natural Sciences. Prior to that he was Program Director of Environmental Biology at the then newly formed National Science Foundation in Washington.

He was listed in *American Men and Women of Science, Who's Who in Ecology,* and *Who's Who in America,* and also is a member of many national and international professional organizations. Most recently he was president of the American Institute of Biological Sciences and active in the American Association for the Advancement of Science, and the American Society of Zoologists.

A nationwide search is in progress to select and appoint a new Chief. Dr. Wallace E. LaBerge, Head of the Faunistic Surveys and Insect Identification Section was named Acting Chief by the Board of Natural Resources and Conservation until a permanent appointee is selected. LaBerge also is chairman of the Staff Search Committee that is now interviewing five final candidates for the vacancy. Other members of the committee are Drs. William Childers, William Edwards, Joseph Maddox, and Kenneth Robertson, and Mr. Robert Ellis with Mrs. Alice Adams serving as the group's secretary.

The committee will present its recommendation on the basis of its activities and solicited input from the entire Survey staff to the Board of Natural Resources and Conservation. The Board has the responsibility of making the final and official

appointment. It is anticipated that the Board's announcement will be forthcoming in the near future.

Mushrooms and Toadstools

A mushroom or toadstool is a fleshy structure that consists of a stalk and a cap with plates of tissue called gills on the underside. The surface of the gills is covered by a layer of cells termed basidia that give rise to the reproductive spores. There is no technical difference between a mushroom and a toadstool as both represent the spore-bearing phases of a fungus. The term mushroom traditionally refers to edible species, some highly prized for their delicious flavors and aromas; and the term toadstool is used for poisonous mushrooms that contain toxic compounds that may cause both illness and death.

Mushrooms can be found throughout most of the year in lawns, roadsides, forests, and prairies. The largest number appear when the first cooling trend of fall is accompanied by rains, usually in September. Warm spring rains also bring out the second largest number of mushrooms including the morels and puffballs.

Edible and poisonous species can occur together and can resemble each other. Thus, safe and toxic species can be confused by amateurs, and there are no quick tests to distinguish the edible from poisonous species. Eating wild mushrooms without learning something about them is like playing Russian roulette. Most of the time, nothing will happen, unless a poisonous species is ingested. For this reason, only people familiar with the technical identification of mushrooms should collect and eat wild species.

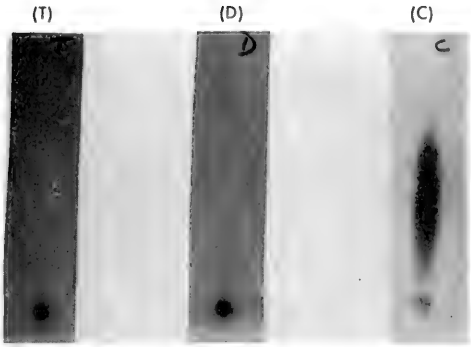
Incdible *Russula emetica* illustrating the stalk, cap and a portion of the gills. Found on rotten wood and rich humus in coniferous forests and bogs (Photo by Leland Crane, Mycologist).

Learning to identify accurately the species that you want to eat as well as those to avoid is the best safeguard. In gathering mushrooms, be careful to collect the entire specimen and keep each kind separate. Collect only fresh specimens for the table; however, young and old specimens may be needed for identification.

Once the identity of a collection is established, check its edibility rating. If the species is rated as poisonous, most people will be poisoned if they eat it. An edible species is one that, when cooked, can be eaten safely in moderate quantities by people in good health. Do not gorge yourself on mushrooms because most people find them hard to digest due to the chitinized walls and the fats and oils in the cells. Eat only cooked mushrooms because certain species are more likely to cause problems when consumed raw than when cooked, and some toxins are inactivated by proper cooking. Do not keep mushrooms for an extended period of time because bacterial contamination may cause food poisoning. Finally, when experimenting with mushrooms, always keep some intact specimens on hand. They may be needed to aid in identification so that the correct treatment can be given in case of accidental poisoning.

Carbofuran in Soils

Insecticides are important tools used in integrated pest management programs for various Illinois crops. Because they are inherently toxic, it is necessary to understand their environmental fate and behavior so that pollution of non-target sites and organisms can be avoided. Knowledge about insecticide behavior also can aid in



Relative movement of Counter® (T), dieldrin (D) and carbofuran (C) on thin layer of soil as recorded on X-ray film (Photo by Les Woodrum, Survey Photographer).

more efficiently controlling the target pest. Studies of the behavior and fate of pesticides are called environmental chemodynamics. They are designed to elucidate the relationships between physical and chemical properties of a pesticide and its fate in the environment.

One aspect of environmental chemodynamics is the potential for movement or leaching of a pesticide in the soil. In the Pesticide Chemistry Lab of the Section of Economic Entomology, Allan Felsot and Jean Wilson have studied the mobility of carbofuran (Furadan®), a widely used corn insecticide applied to soil. The studies were performed in the laboratory using a combination of soil, thin-layer chromatography, and autoradiography. Briefly, a soil-water slurry was spread across a glass plate and allowed to dry. Radioactive-labeled carbofuran was spotted on the plate near the bottom end. The bottom edge of the plate was placed in water. The water was allowed to move up the plate to a distance of 10 cm. Afterwards, the plate was covered with a piece of X-ray film for a few weeks, and then the film was processed. Wherever the labeled pesticide was located on the plate, a dark area appeared on the film. The developed X-ray film thus served as a record of pesticide movement under leaching conditions.

Because carbofuran has a relatively high-water solubility compared to other widely used soil insecticides (such as dieldrin and Counter®), it has more potential for movement in the soil. Conversely, chemicals with very low water solubilities (e.g., dieldrin) are adsorbed by the soil matrix to a greater extent and would be expected to exhibit a very low leaching potential. It was observed that carbofuran adsorption by soils was generally one hundred times lower than dieldrin adsorption, and carbofuran consequently was spread across the thin layer of soil while dieldrin was found near the bottom. Thus, as carbofuran adsorption decreased, its leaching potential increased. These results help to explain why similar runoff losses of dieldrin and carbofuran from watershed areas have been observed. Dieldrin is mostly associated with runoff sediment, whereas carbofuran is mostly associated with runoff water.

Lake Michigan Diversion Project

The 300-mile Illinois River stretches from Chicago to Grafton and is blessed with over 100 bottomland lakes and sloughs. These backwater areas make the river unique and once were a paradise for fish and wildlife, and their decline may be accelerated by the Lake Michigan Diversion Project. Stephen P. Havera, Frank C. Bellrose and other wildlife specialists at the Havana Field Station are investigating what effects the proposed, water-diversion project will have on the surface area, volume, and depth of the backwater lakes.

A total surface area of 28,600 hectares (70,670 acres) of bottomland lakes presently occurs in the Illinois River Valley when the river level is at tree line. The Peoria Pool (Peoria to Starved Rock) and LaGrange Pool (LaGrange to Peoria) constitute 85 percent of the area. There is little bottomland area above Starved Rock because of the narrow river valley northward. From Grafton to LaGrange numerous bottomland lakes in the Alton Pool have been eliminated by drainage and leveeing for agricultural purposes. The volume of the bottomland lakes is approximately 144,000 acre-feet. The average depth of the lakes is currently and despairingly only 0.62 m (2.04 ft), primarily because of the high rate of sedimentation from soil erosion on agricultural fields.

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The Lake Michigan Diversion Project will sufficiently increase the surface area and volume of the bottomland lakes in the Illinois River Valley to inundate an undeterminable amount of bottomland timber. Water from Lake Michigan currently is being diverted into the Illinois River at 3,200 cubic feet per second (cfs). The proposed diversion project calls for the rate to be increased to either 6,600 or 10,000 cfs, mainly during the customarily low water periods. However, it is estimated on the basis of a U.S. Army Corps of Engineers' computer model that even during these periods the extra diversion water will adversely affect the bottomland habitat even if the 6,600 cfs rate is selected.

The increased diversion will further accelerate the already extreme rates of sedimentation in the bottomland lakes. The higher water level will allow more sediment to settle in the lakes thereby increasing the rate of fill. If diversion was then discontinued, the average depth of the lakes would be less than if no greater diversion was initiated.

The proposed increased diversion will have the least impact upon bottomland forests, mudflats, and storage capacity of the bottomland lakes in the Upper Pools of the Illinois River Valley because of the greater rate of fall and lack of bottomland areas in the Upper Pools than downstream. The Peoria Pool will be affected the greatest by increased diversion because most of the bottomland lakes are connected directly with the river. Therefore, any fluctuations in river levels will immediately affect the depth, surface area, and volume of the associated bottomland lakes. In the LaGrange and Alton pools, natural and man-made levees protect bottomland areas from some of the fluctuations in river levels. Hence, although changes in depth, surface area, and volume would occur, the effect of increased diversion on bottomland areas in these pools should be less than in the Peoria Pool.

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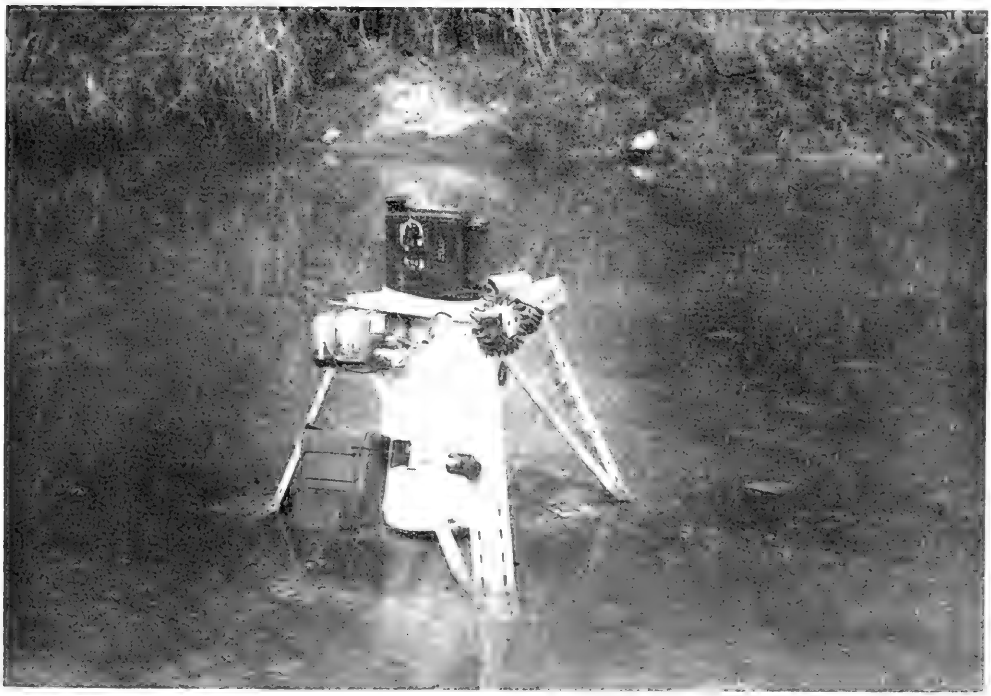
Underwater Home Movies

Within the Aquatic Biology Section, a great deal of the research is aimed directly at solving important and urgent problems. Water pollution, fisheries management, weed control, and many other problems receive the constant attention of Survey aquatic biologists. In addition to these efforts, scientists also study aspects of aquatic biology which, at first glance, appear to have much less potential for practical application. This first glance, however, can be deceiving.

For example, aquatic biologist Mike Wiley can occasionally be seen standing in the shallow waters of agricultural ditches and small streams around Champaign adjusting one or more tripod-mounted 8-mm movie cameras. The cameras are used to make underwater time-lapse movies of various aquatic insects and other invertebrates. The filming may continue for up to



Time-lapse movie equipment filming aquatic insect behavior in the Middle Fork of the Vermilion River near Flatville. (Photo by Mike Wiley)

3 days, as attached strobe lights fire at 10–30-second intervals, casting a strange, bright, pulsing light on stream banks and adjacent fields at night. By carefully analyzing the films, Wiley can examine the many events and behaviors that together constitute the daily lives of these small aquatic animals.

Why are state-supported scientists engaged in such seemingly peculiar studies? Just as a mechanic who doesn't understand how an engine works cannot do a good job of diagnosing and repairing it, aquatic biologists cannot provide information and guidance on complex environmental issues unless they first understand how aquatic organisms and communities function. By studying the behavior of aquatic invertebrates, biologists like Mike Wiley find answers to such basic questions as: How do these animals live? What do they eat? How much food is available?

From the answers to these basic questions comes an understanding of what determines the size and distribution of various invertebrate populations. The small invertebrates living in our creeks and drains provide the food for many larger insects and minnows, which in turn are eaten by sport fish, such as bass and catfish. Improving our management of sport fishes, then, depends upon a fairly sophisticated understanding of the insect populations on which the fishes feed.

All of the sections of the Natural History Survey maintain programs in basic as well as applied research. They do so because understanding how nature works is an important prerequisite to working with nature and getting nature to work with us. Even though basic research often appears strangely impractical at first glance, it is important to remember that, like underwater home movies of insects, these studies are often essential to our knowledgeable use of our state's living natural resources.

Poisonous Plants

The word "poison" is often used with plants when only the word "caution" is warranted. Quite a number of plants can cause discomfort, pain, or illness, but few are lethal. The three types of injuries caused by plants are internal poisoning, dermatitis, and allergy.

Although many kinds of mushrooms are perfectly safe to eat, some are extremely toxic, and only a few bites can kill an adult. Some flowering plants also are potentially dangerous. The most important ones found in the wild in Illinois include pokeweed (*Phytolacca americana*), poison hemlock (*Conium maculatum*), water hemlock (*Cicuta maculata*), nightshade (*Solanum* species), and jimson weed (*Datura stramonium*). A few garden plants are also toxic, including yew (*Taxus* species), lily-of-the-valley (*Convallaria majalis*), daphne (*Daphne mezereum*), the leaf blades of rhubarb (*Rheum rhaponticum*), and castor bean (*Ricinus communis*).

Children, because of their inquisitive nature and tendency to put things in their mouths, are especially apt accidentally to ingest plant materials.

The most frequent cause of plant-induced irritation of the skin is poison ivy (*Rhus radicans,* also called *Toxicodendron radicans*), which is abundant throughout Illinois. A few other plants can cause dermatitis, including poison sumac (*Rhus vernix*), trumpet creeper (*Campsis radicans*), and some spurges and poinsettia (*Euphorbia* species). Stinging nettle (*Urtica dioica*) and wood nettle (*Laportea cordata*) have stinging hairs that cause immediate, intense pain; one or both of these plants are found almost anywhere in Illinois. Some plants cause dermatitis in an indirect manner by making a person hypersensitive to light. For example, areas of the skin that come into contact with wild parsnip (*Pastinaca sativa*) and are then exposed to sunlight can develop symptoms similar to those caused by poison ivy. The situation is different with a number of other plants, where hypersensitivity results only when the plant is eaten; this phenomenon is not well understood, and fortunately, few people are affected.

A fairly large number of people suffer from allergic reactions to plants. Certain people are allergic to particular plant foods, such as wheat, flour, beans, tomatoes, chocolate, nuts, corn, and peanuts. "Hay fever" is an allergic reaction to

Poison ivy, *Rhus radicans*. Several other plants have similar leaves, but until you learn to distinguish them, abide by the old adage, "Leaflets three, let it be." (Photo by Kenneth R. Robertson)

microscopic airborne pollen and spores. In Illinois, there are three peak seasons for hay fever. In early spring, much pollen is shed by many common trees, such as ash, birch, elm, maple, oak, poplar, and sycamore. Many of the wild, yard, and crop grasses flower in midsummer, causing another peak in the pollen count, but the greatest amount occurs in fall when ragweed and a few other weeds shed tremendous quantities of pollen.

A great deal of other interesting information about plants is included in the recently published Illinois Natural History Survey Circular 55, *Observing, Photographing, and Collecting Plants,* by Kenneth R. Robertson. A copy may be obtained by writing to the Illinois Natural History Survey, Natural Resources Building, Champaign, Illinois 61820.

Serendipitous Entomologist Makes Discovery

Serendipity is not one of the abilities which scientists must have to be employed at the Natural History Survey. However, the "gift for finding valuable or agreeable things not sought for," as Webster defines serendipity, is always welcome. A case in point is that of economic entomologist Robert J. Barney, who in the spring of 1979 was studying the migration of the alfalfa weevil and its predators into and out of alfalfa fields.

As a part of this study, Barney placed pitfall traps along the edge of an alfalfa field 2 miles south of Lively Grove, Washington County, and 13-17 meters into a woods of oak with some hickory interspersed that bordered the field. The traps were made of galvanized metal guttering cut into 1-meter lengths and fitted with end caps. The pitfall traps were set in the ground flush with the soil surface and were half filled with ethylene glycol. Any insects that walked up to the traps would fall into them and be preserved there. The trapped insects were regularly removed and identified.

Trapping was begun on May 15. Imagine Barney's surprise on June 13 when he discovered that his traps contained specimens of a dung beetle, or tumble bug, that had never before been found in Illinois.

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This beetle, *Deltochilum gibbosum gibbosum,* was previously known from Florida, Georgia, Alabama, Mississippi, Louisiana, North Carolina, South Carolina, Texas, Tennessee, and southeastern Kentucky. Its discovery in southwestern Illinois extended its known range by over 100 miles.

More than 70 percent of the beetles trapped were found between June 13 and July 3. The ratio of females to males was 2 to 1. These beetles were found in both the field-edge and the woods traps, most being found in the woods.

The Natural History Survey is charged with the responsibilities of identifying the insects and other animals of the state and publishing reports on them. Usually these kinds of work are very straightforward activities. But once in a while even scientists like to enjoy a little serendipity.

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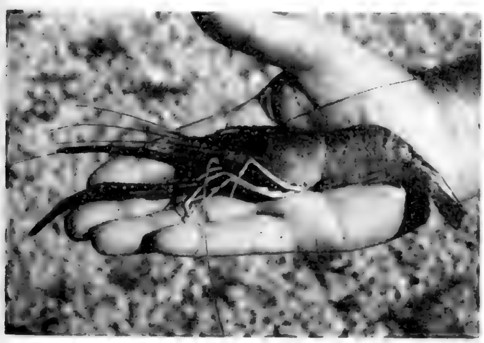
Aquaculture, Potential New Industry for Illinois

Aquaculture, the practice of growing aquatic organisms in freshwater systems, appears feasible, practical and potentially profitable in Illinois. Catfish, trout, carp and prawns are some of the organisms that have been grown successfully in the state. A literature study recently completed by Robert Gordon, INHS, and Randy Westgren, University of Illinois Agricultural Economics, and funded by the Institute of Natural Resources has shown that the technology for aquaculture is now well developed for various culture methods including raceways, silos, cage and pond culture. Farm ponds, reservoirs, strip mining lakes, cooling lakes and streams are suitable systems for various types of aquaculture.

Types of organisms, stocking rates, types of feed, growth rates, diseases, environmental problems, harvesting methods and marketing problems have been or are now being studied. These results suggest that good aquaculture businesses may expect profits ranging from $625 to $1,250 per hectare per year when raising catfish which sell for $2.80/lb retail. Profits may vary according to the individual system in use. Small operations are less likely to be profitable than are larger systems due to various fixed costs. Catfish ponds of 20-acre size with multiple ponds are recommended. Costs for construction, personnel, equipment, land, buildings, advertising and processing have a direct impact on the success of any operation as do disease and wise aquaculture practices.



Prawn grown in Illinois (Photo by Homer D. Buck, Aquatic Biologist).

Our studies suggest that by good management practices, hard work and perseverance, a farmer can show a profit in aquaculture within a few years under current conditions. As the number of aquaculture systems and the markets for aquaculture products increase, the data suggest that greater profits will be realized in aquaculture in Illinois.

In Ilinois ca. 100-200 acres of water are currently known to be used for the culture of commercial catfish. Fishout ponds in use may raise this number to 300 acres. By contrast, Arkansas (12,000) and Mississippi (25,000) are the leading states in acreage registered for the production of catfish. The largest population centers in Mississippi range from 40,000 to 260,000 while the populations of St. Louis and Chicago are approximately 2 and 7 million people respectively. Thus, the market potential for aquaculture products in Illinois far surpasses that of the southern states.

The more rapid growth of catfish in southern climates may be offset by the increased costs of transportation of aquaculture products to northern markets. Catfish can be grown to marketable size (i.e., 1.5 lb) in Mississippi in 2 growing seasons while 3 seasons are required in Illinois.

Overall the prognosis for aquaculture as a viable branch of agriculture in Illinois is good to encouraging. The technology is available now and is improving. With the initiation of a government program to stimulate the development of aquaculture through the U.S.A., coupled with the potential markets in the regions, there are substantial opportunities for investments in aquaculture in Illinois.

Sampling Methods in Soybean Entomology

A source book entitled *Sampling Methods in Soybean Entomology* recently was published under the co-editorship of Marcos Kogan, Section of Economic Entomology, INHS, and Agricultural Entomology, University of Illinois, and D. C. Herzog, Department of Entomology and Nematology, University of Florida. It is the first synthesis of techniques and study results on sampling arthropod populations for a specific crop. The book is designed to promote quality research on soybean-associated arthropods and to help integrated pest management (IPM) specialists objectively evaluate local insect problems. However, Kogan points out that it is not a control manual.

The dramatic increase in the level of soybean production in Illinois and elsewhere in the world since the 60's brought with it a need for more entomological research. One program that was created to fill this vacuum is the U.S.D.A.-sponsored "Regional Project S-74: Tactics and Management Systems for Arthropod Pests of Soybean." The Survey and the University of Illinois participate in the project along with several other institutions.

Kogan recognized the need to standardize the methods being used to sample the populations of soybean arthropods, especially in the research of determining levels at which insects can cause economic damage and in evaluating effectiveness of biological control agents. He proposed the idea to the S-74 participants in 1976, emphasizing the necessity of being able to compare the results of research from one state to another.

Kogan and Herzog, as co-editors worked with 30 authors from various state, national, and foreign programs in order to comprehensively cover the subject of soybean entomology. Authors from the Survey and the University of Illinois besides Kogan are C. E. Eastman, C. G. Helm, M. E. Irwin, W. G. Ruesink, and G. P. Waldbauer. Besides emphasizing sampling methods, the book is a compilation of information on the distributions, life histories, and nature of damage of commonly encountered soybean pests. L. D. Newsom points out in his forwarding comments that the book's coverage is sufficient to make "control procedures possible for most of the world's major arthropod pests of soybeans."

Persons interested in copies of *Sampling Methods in Soybean Entomology* may order them from the publisher, Springer-Verlag, New York.

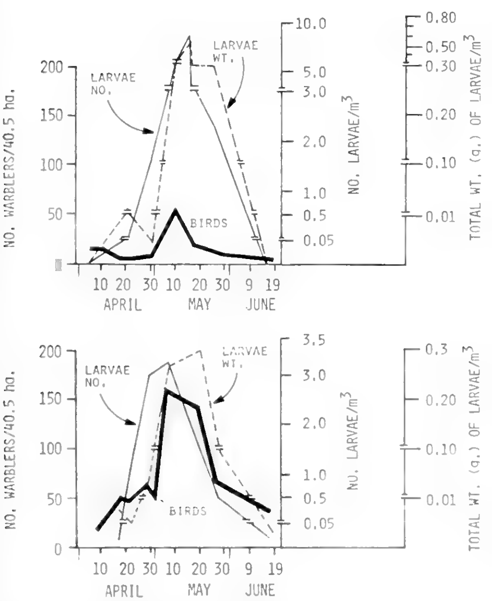
Migrant Warblers and Illinois Forests

The people of the United States, by treaty with Canada and Mexico, have agreed to protect nearly all species of migratory birds. In practice the degree of protection varies from country to country and, in the United States at least, from species to species. For species of waterfowl, food and relatively large areas of habitat are provided the birds during their stay in the U.S.A. While hunting of some waterfowl is allowed, the populations are measured each year, and strict limits are placed on the numbers killed to insure sustaining populations of each species.

Protection of migratory non-game birds has been limited mainly to making it illegal to purposely kill them, though many thousands are killed accidentally each year on television towers and other structures. The over-all effect of that mortality is unknown. Potentially more serious is the fact

that there are no specific habitat refuges for most non-game species and no restrictions on habitat destruction. Even more serious is the fact that there have been no systematic measurements of migrant songbird populations, and, except in a very general way, there is little knowledge of habitat and food requirements or food availability for these species. To find out more precisely how many migrant birds are using Illinois forests, Survey ornithologists Jean and Richard Graber began in 1979 to make daily censuses of migrants in four arboreal habitats: bottomland forest, upland forest, shrub and forest-edge, and pines. Because many migrants are insectivorous, a concurrent study was initiated on food availability in the same habitats. With 2 years of field work completed, the researchers are now analyzing data on the wood warblers (Parulidae), one of the most numerous and most beautiful groups of birds in Illinois.

At the peak of spring migration the densities of warblers in bottomland forest were about 5 times the breeding populations. How does the forest accommodate such numbers? The answer appears to be



Numbers of warblers, numbers of insect larvae (Lepidoptera) and biomass of larvae during 1980 spring migration in upland forest (top graph) and bottomland forest (bottom graph) in southern Illinois.

that the migrants coordinate their arrival to the time when insects are most abundant. The insect censuses revealed that over 96 percent of the invertebrate biomass on forest foliage in spring was larvae (mainly Lepidoptera), and virtually every time the Grabers observed a warbler with food, the food item (prey) was a caterpillar-like larva. The peak of warbler migration coincided with the peaks of both numbers and bio-mass of insect larvae. A similar matching curve (not shown) was found for all species of arboreal foliage gleaners, except the tiny sylviids (kinglets) which peak early in the larvae season, possibly to catch the earliest (smallest) caterpillars.

The population of migrant warblers was more than 3 times greater in bottomland than in upland forest. It is perhaps not surprising then that the peak insect larval population in the upland was twice that of the bottomland forest. Although it is tempting to try and draw conclusions about the effect of the warblers on caterpillar populations, much more study is needed on such questions as annual variation in all populations, on the warblers' foraging rates and other activity patterns, on the warblers' particular choice of prey and the particular availability of that prey, the nutritional value of the prey, etc., before doing so. That work is continuing, but for now the data emphasize the importance of bottomland habitats not only to our nesting species but also to the migrants, coming and going. With conventional agricultural methods, it is relatively easy to provide grain for visiting waterfowl, but for most of our transient species there is no other way to meet their requirements than to preserve the natural habitats that sustain them.

Horse Flies and Deer Flies

The tabanids or horse and deer flies are well known to dairy farmers and livestock producers as well as to campers, fishermen and outdoor enthusiasts as annoying and often painful inhabitants of most wooded areas in Illinois. These large and persistent flies impart a painful bite and can occur

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in sufficient numbers to make canoeing and hiking virtually impossible.

Tabanids are vectors of several diseases of man and animals caused by viruses, bacteria, rickettsia or rickettsia-like organisms, trypanosomes and filarial worms. Although some diseases transmitted by tabanids occur in Illinois, only anaplasmosis is a reasonably common occurrence in the spring and fall, but basically is found only in southern Illinois.

From 1978-1980, a faunal study of the horse and deer flies of Illinois was carried out by survey entomologist Donald W. Webb with field collecting done by Edward A. Lisowski. The study, which is part of an ongoing faunal study of several groups of flies in Illinois, resulted in the collection of over 15,000 specimens.

The collecting program concentrated on the peripheral counties, particularly in the marshes and swamps of southern Illinois; sand marshes of Iroquois County, sphagnum bogs, dunes and marshes of Lake and McHenry counties; and along the Illinois River and Mississippi lowlands of western and northwestern Illinois. Since female deer flies readily attack man, specimens were easily caught with an aerial net as they swarmed around the collector's head. Horse flies which are more mobile and attack man less voraciously than deer flies were collected in Malaise traps (8 x 60 ft piece of insect netting strung across paths and fire lanes). Malaise traps were located at special locales in Pope, Mason and Ogle counties to provide information on the seasonal flight patterns of various species.

On the basis of the recently collected material and previous holdings of horse and deer flies in the collection of the Survey's Section of Faunistic Surveys and Insect Identification, 86 species and subspecies definitely are found in Illinois. An additional 23 species are known to occur in the surrounding states and have a strong likelihood of occurring in Illinois.

A manuscript on the adult tabanids of Illinois has been completed in cooperation with Dr. L. L. Pechuman, Cornell University. In addition, Dr. H. Teskey of the Biosystematic Research Institute, Agriculture Canada, has cooperated in providing descriptions, illustrations and keys to the larval stages of Illinois tabanids. The published bulletin on the horse and deer flies will provide keys to the males and females of each species, as well as to the known larvae, and will give descriptions of their diagnostic characters, emergence periods, distributions and biologies.

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NATURAL HISTORY SURVEY REPORTS

Clear-cutting and Gray Squirrels

Before 1960, foresters used single-tree or small-group cutting to harvest trees in the eastern hardwood forests. Such limited cutting did not seriously affect gray squirrels if less than 50 percent of the merchantable volume of trees was removed. Since 1960, research has demonstrated that eastern hardwoods cannot be reproduced with satisfactory composition by the use of single-tree harvesting. Instead, clear-cutting, which completely removes woody stems larger than 2 inches diameter at breast height (dbh), has been found to produce stands well stocked with commercially valuable species.

Obviously, complete tree removal will also remove tree-dwelling wildlife, including gray squirrels. Foresters and wildlife biologists need information regarding the constraints on timber harvesting, such as the size of clear-cuttings, that are necessary to perpetuate wildlife species that are adversely affected by the practice.

Survey wildlife biologist Charles M. Nixon and his co-workers in Ohio have just completed an 8-year investigation of the effects on gray squirrel populations of clear-cutting mature hardwoods, using clear-cuttings varying in size from 5.7 to 32 acres and in age from 0 to 22 years. On two study areas, gray squirrels were trapped and marked for 2 years before clear-cut logging to investigate the influence of these cuttings on squirrel densities, individual movements, and recovery rates. Four additional small clear-cuttings, 7-9, 15-17 (two areas), and 20-22 years old, were used to determine squirrel presence and squirrel food production up to 22 years after logging.

They found that captures of gray squirrels declined 51.5 percent and estimated densities declined 44 percent in the first year following the clear-cutting of 32 acres of the best hardwoods within a 206-acre study area. Recovery rates for marked adult gray squirrels whose home ranges included the clear-cutting were lower than rates for adults not exposed to clear-cutting. Fewer than 20 percent of the adult squirrels known to be living adjacent to the clear-cut area were captured within the cut area in the first 2 years after cutting.

In a companion study of two smaller, narrower clear-cuttings (9.4 and 19.5 acres) on a 188-acre stand of hardwoods, no significant changes in squirrel densities, recovery rates, breeding rates, movements, or body weights were observed after clear-cutting. The recovery rate for adult females was significantly higher on this area compared with that of females on the area with the 32-acre cutting.

On these cuttings and the older ones studied (7, 15, and 22 years old), squirrels ventured significantly farther into a clear-cutting during winter than after leaves appeared. Clear-cuttings less than 22 years old contained less food for squirrels than did uncut forests. Thus, gray squirrels using cuttings less than 22 years old were considered to be transients, but they did forage significantly farther into 15- and 20-year-old clear-cuttings than into the 7-year cutting.

A recent clear-cutting of hardwoods in the Midwest. All woody stems greater than 2 inches in diameter are cut to allow rapid growth of new seedlings and stump sprouts.

At least two characteristics may render 1- and 2-year-old clear-cuttings unacceptable habitat for foraging gray squirrels. First, logging residues and the luxuriant growth of annual forbs restrict the squirrels' ability to detect predators. Even in winter squirrels in clear-cuttings traveled mostly on downed tree limbs, rarely venturing to the ground.

A second reason why squirrels may avoid a recent clear-cutting is the lack of staple foods. No winter-storable foods were produced until 15 years after cutting. Squirrel foods were particularly scarce during the first two growing seasons, when only fungi, flowering dogwood drupes, and grapes were produced in quantity.

It was apparent from these studies that large (more than 30 acres) clear-cuttings must be avoided if wildlife species that prefer mature hardwood habitats are to survive.

Therefore, in considering a size limitation on clear-cuttings, the home range of the adult female gray squirrel was used as a guide toward minimizing the effects of clear-cutting on this species. A mean home range of 5.2 acres was found for adult females livetrapped on three study areas in southeastern Ohio a minimum of eight times during 2 or more years (N = 51). The diameter of a circle encompassing an area of this size is about 530 feet. Clear-cuttings kept narrower than this distance should allow most squirrels to retain some portion of their original home range and should enhance their chances to tolerate the logging operation.

The length of narrow clear-cuttings will be determined by site-class differences, topography, logging constraints, or conflicts with travel and stream protection zones. If cutting units exceed 20 acres, the wildlife biologists recommend retention of uncut travel lanes of mature trees, 50-100 yards wide, to permit squirrels and other wildlife to cross clear-cuttings. These travel lanes would be required for about 30 years after cutting to allow trees within clear-cuttings to reach seed-producing age. Travel lanes should be cut selectively, using single-tree or small-group cuttings to perpetuate a stand capable of producing at least 100 pounds of winter-storable food per acre. Recommendations for the amount of shelter necessary to maintain huntable numbers of gray squirrels are not documented, but in Illinois, gray squirrels were not present in stands with fewer than three tree cavities per acre.

Because of extensive cutting between 1890 and 1935 in the eastern hardwoods, most stands are now approaching commercial maturity. Foresters and wildlife managers thus have an opportunity — one that will not occur again for a whole timber

rotation (80-120 years) — to begin adjusting timber age-classes in most forests.

Yields of both timber and gray squirrels can be maintained through long-term planning of cuttings over large units of forest. Use of small (less than 20 acres), narrow (less than 530 feet), carefully located clear-cuttings in forests where 40-60 percent of the stands are retained in a seed-producing age should not materially reduce gray squirrel populations.

Cutting-Rot Susceptibility

The propagation of softwood cuttings is an important method for producing many landscape tree and shrub species. A mist propagation technique involves the mechanical spraying of water over leafy cuttings to maintain a thin film of water on the plant tissues. The high humidity promoted by mist, and its cooling effect on plant foliage, allows the propagator to expose cuttings to full sunlight without fear of leaf wilt. During the mist propagation phase, softwood cuttings are especially susceptible to attack by fungal pathogens. *Pythium, Phytophthora,* and *Rhizoctonia* are three genera of pathogens often implicated in the cutting-rot problem.

Economic losses from pathogen attack during propagation can be considerable, since thousands of adjacent cuttings may be involved. More serious is the problem of diseased rooted cuttings being transferred to the field with latent infections. These plants are likely to decline or die when later exposed to such stresses as transporting shock, poor drainage, or unfavorable weather. Very little research has focused on pathogen-host species interactions during propagation. Mary Ann Smith and Dan Neely, Survey plant pathologists, have completed a study that evaluated the disease reaction of 16 woody host plants to the three pathogens.

Results of the screening tests indicated that plant species had markedly different levels of susceptibility to the three cutting-rot pathogens. In 40 percent of the combinations, severe cutting rot developed. In 15 percent of the combinations the plants exhibited no disease symptoms. In many of the combinations the plant survived infections by producing a well developed root system above a basal rot lesion.

As shown in the table, smoke tree, deutzia, buckthorn, and sumac were highly susceptible to all three pathogens. Only privet exhibited low susceptibility to all of the pathogens.

This research established the ability of fungal isolates from three genera to cause disease on 16 woody plant species. The patterns of development of basal rot, root rot, foliar necrosis, and defoliation were defined. This information will be helpful to propagators and nurserymen in diagnosing and treating the disease problems encountered with mist bed operations.

Relative susceptibility of cuttings to inoculation with three genera of fungal pathogens.

Cutting	Rhizoctonia	Phytophthora	Pythium
Red ozier dogwood	High	Low	Low
Smoke tree	High	High	High
Cotoneaster	Moderate	High	Low
Deutzia	High	High	High
Winged euonymus	Moderate	Low	Moderate
Forsythia	Low	Moderate	Moderate
English ivy	Moderate	Moderate	Low
Privet	Low	Low	Low
Honeysuckle	Moderate	Low	Low
Star magnolia	High	High	Moderate
Bayberry	High	High	Low
Buckthorn	High	High	High
Jetbead	Moderate	High	High
Sumac	High	High	High
Alpine currant	Moderate	High	Moderate
Dwarf cranberry	Moderate	Low	Moderate

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Survey Scientist Participates In International Exchange

International exchange of information has become increasingly important in aquatic biology, as foreign fishes, such as the Chinese carps and Nile perch, are brought to this country with little understanding of the impact they may have on our natural ecosystems. As an example of attempts to extend international contacts with biologists, R. Weldon Larimore of the Survey's Aquatic Biology Section has recently participated in a Fulbright lectureship at the University of Nis, Yugoslavia, where he delivered a series of lectures and worked with a group of graduate engineers on the effects of impounding a small stream in northeastern Yugoslavia. Expected changes in water quality and in the biological communities above, below, and within the impoundment were considered. Larimore and his group formulated a long-range plan for the development of the sport fishery in this area that is intensively used by Yugoslavs for rest and recreation.

On his way to Yugoslavia, Larimore spent several days with biologists at the Fishery Research Station, Szarvas, Hungary. Scientists at this station are doing advanced work in fish culture, fish genetics, and the use of animal wastes in fish production. Their work on the grass carp and its hybrids has been of particular interest to American biologists because of the potential of this fish for controlling aquatic weeds in this country. Survey aquatic biologists Homer Buck and David Philipp have cooperated with the Hungarian biologists on this work and were pleased to have new information gathered personally by Larimore. Larimore also visited the Hungarian Institute of Limnology and discussed with scientists their studies of exploitation of lake fishes and the potential for further commercial production.

In western Yugoslavia, Larimore visited several large fish farms and led a discussion at the University of Zagreb concerning environmental laws and their economic impacts in eastern Europe and America.

Larimore's visit to eastern Europe has stimulated further activities between foreign and Natural History Survey scientists. Not only are Survey biologists in closer contact with the foreign projects, but in the near future two biologists from Yugoslavia and one from Hungary will come to Illinois to exchange ideas with Survey scientists.

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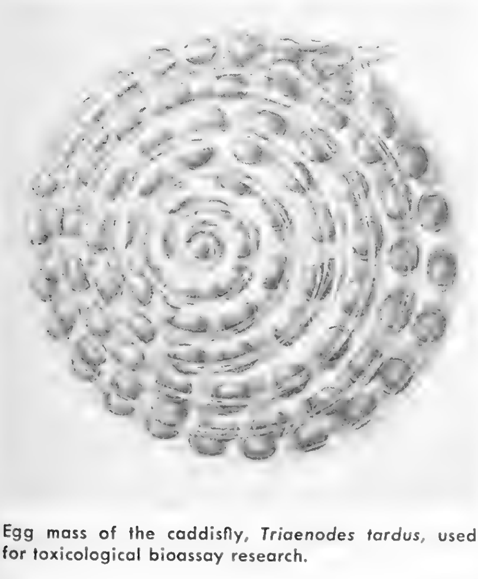
NATURAL HISTORY SURVEY REPORTS

Caddisfly Egg Toxicity Bioassay

What are the effects of insecticide and herbicide runoff from farm fields in Illinois on the embryological development of aquatic insects? To answer this question Illinois Natural History Survey biologists David Belluck and John Unzicker along with University of Illinois graduate Barbara Pennington selected the pond dwelling caddisfly *Triaenodes tardus* Milne (Trichoptera: Leptoceridae) as a representative aquatic insect. A new toxicological test, the caddisfly egg toxicity bioassay which used the eggs of *T. tardus,* was developed to study the effects of pesticides on the egg development of this common Illinois caddisfly.

T. tardus is widely distributed in North America. It is transcontinental in Canada and the northern United States and extends north into Alaska. In the central and southern United States it occurs from the east coast west to the Rocky Mountains. The aquatic stages are found in lakes, ponds, marshes and in areas of slow current and in medium to large rivers where they are always associated with vascular plants from which they construct a case of spirally arranged leaf fragments.



Egg mass of the caddisfly, *Triaenodes tardus,* used for toxicological bioassay research.

During the summers of 1979 and 1980, 40 pesticides were screened for ovicidal activity using the caddisfly egg toxicity bioassay. To obtain eggs for this test, gravid females of *T. tardus* were attracted to an ultraviolet light trap set up within 90 min. of darkness at the Illinois Natural History Survey research ponds. Females were captured with an aspirator and transported to the laboratory where their extruded egg masses were removed with a forceps and placed in a cup of filtered pond water. Egg masses were then placed in prepared solutions of pesticides and stored on shelves at a constant temperature of approximately 26°C. An experiment was terminated with the successful hatch or death of the last egg in the egg mass (usually between 2 to 3 weeks after oviposition).

Analysis of the toxic effects of selected insecticides and herbicides on the egg development of the caddisfly *T. tardus* indicates that these animals are very sensitive to the presence of pesticides in solution. Toxicity levels varied within and between different classes of insecticides and herbicides. Herbicides were found to be toxic to

eggs of *T. tardus* from 1.26 parts per million to 114.30 parts per trillion, and insecticides were toxic from 2.90 parts per million to less than 10 parts per trillion.

While it is difficult to accurately predict the toxic effects of pesticides to organisms in the field from laboratory derived data, tests such as the caddisfly egg toxicity bioassay attempt to bridge such gaps. Laboratory exposure of field-captured aquatic insect eggs to toxicants can show the potential effects of a particular chemical upon those organisms if the chemical was to be applied in the field. Additionally, the low cost and simplicity of the caddisfly egg toxicity bioassay permits organizations with limited budgets and/or staff expertise to conduct toxicity tests on a local basis.

Migratory Peregrine Falcons

Survey biologists William W. Cochran and Arlo Raim conducted studies of migratory peregrine falcons in the spring and fall of 1979. Transient migrants, monitored with miniature radio transmitters, spent up to one month in southern Texas (Brownsville area) before continuing their spring migration. During an 8-day winter survey in southern Texas, only one peregrine was sighted. By contrast, in the April study no fewer than 4 and an average of 7 peregrines were sighted per day over the 1-month period. The spring/winter ratio of sightings (56:1) supports the view that the 15-bird spring sample was of transients.

The northward headings from southern Texas raised some questions as to the wintering areas of the observed peregrines because there is relatively little land directly south of Brownsville. Migrant peregrines reaching southern Texas from South America and most of Central America would have to travel considerably northwest, not north. Thus, it may be concluded that a migratory direction change takes place for some peregrines after they reach southern Texas, based on the census data showing only few winter residents of the area.

Banding and visual data verify a significant "turn" in migration for only a few bird species. One example is the whistling swan, which heads NNW from its Chesapeake Bay wintering site to favorable feeding areas in the Ontario-Michigan (Detroit) region where it spends several weeks. It then departs almost straight west for the Dakotas where it remains for several more weeks before again switching direction significantly to the NNW.

For the swan it can be shown that the stops occur where shallow-water habitat is favorable for feeding. Peregrines can probably do well enough anywhere they can find prey species. However, the southern Texas area, and especially the barrier islands, have considerably more prey than the comparatively barren areas of western Texas and northeastern New Mexico, which northwest-bound peregrines would reach if they continued on the course that brought them to southern Texas. Thus, it is a good place to make a turn to the north where prey is available. However, it is not known why the peregrines layover in southern Texas until May. Perhaps the turn is not a "behavioral" change in the "method or cues" for orientation. If the cues are celestial, they must be given time to change. For example, during April the sunset direction is moving quite rapidly clockwise to the north. From April 4 to April 27 this change amounts to 11 degrees, which is in the needed direction but only one-half to one-third the change that the peregrines must make if all the turn is made during this interval and in southern Texas.

The fall studies, based on a sample of 10, showed that transient peregrines trapped on Assateague Island continued their magration in a variety of directions from SE to SSW. There is also weak evidence that many of these migrants spend up to 2 or perhaps 3 weeks along the coast before proceeding. One of the study birds spent at least 10 days on Assateague before heading south. It is known from band-return information that peregrines reach Assateague from directions ranging from NW to NNE. This virtually precludes any solid comment based on a small sample.

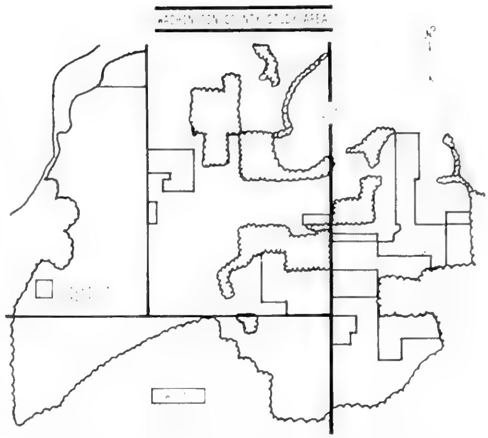
Alfalfa Weevil Migration

The alfalfa weevil has been the most common and destructive pest of alfalfa in

Illinois for nearly two decades. The damage is done primarily by the larvae feeding on the tender growing tips of the alfalfa plant for three or four weeks in the spring. When the larvae are fully grown they spin silken cocoons on the plants or in the ground litter and pupate. The pupae transform into adults in one or two weeks which, after feeding briefly in the spring, migrate to protected areas (particularly wooded areas) in the vicinity of the alfalfa fields where they enter a resting period called aestivation. In Illinois, most of the adults will return to the alfalfa fields in late summer and early fall.

For the past several years, two Survey entomologists, Robert D. Pausch and Stephen J. Roberts have been studying the movement of adult alfalfa weevils in and out of alfalfa fields in Washington County in southern Illinois. The studies have resulted in a better understanding of this pest of alfalfa and have produced a new concept of pesticide usage. Pausch and Roberts have shown that the migration of the adult weevil into alfalfa fields after leaving their sites of aestivation is first a gradual movement across the soil surface. Flight occurs only after the weevils have been in the field for a considerable length of time and have been able to restore their depleted energy resources by feeding. Because of the delayed flight activity, the majority of the weevil population is concentrated in a relatively narrow band at the edge of the alfalfa fields and is in a relatively immobile state. These conditions argue well for controlling the fall adult weevil population with insecticides.

Pausch and Roberts currently have research underway to more fully investigate various ways of controlling the alfalfa weevil with a fall, adult-control program. Preliminary tests in the development of this new concept have been encouraging. Two fields of approximately the same size and with approximately the same size populations of alfalfa weevils were used to test the idea. A 60 ft-wide perimeter band of one field was sprayed with an insecticide at a time when the Survey researchers estimated that the majority of the weevil population was contained within the band.



Study area of alfalfa weevil migration and control in southern Illinois.

The second field was left unsprayed and served as a control. Both fields were monitored very closely the following spring to follow the development of the weevil larvae. In the unsprayed control field, the weevil population developed to the point where the field had to be sprayed for the larvae or else the entire first cutting would have been lost. The larval population in the sprayed test field remained low, and an excellent first cutting of alfalfa was made without applying any additional insecticide.

It must be pointed out that although the first trial of this new concept of alfalfa weevil control was encouraging, more research needs to be done. To this end, entomologists Pausch and Roberts have expanded the scope of their research and will be studying the effectiveness of different application rates of selected insecticides, band widths, and timing of application in various areas of the state.

Aquatic Biology Training Programs

Many on-the-job training experiences are available for college students in the Survey's Section of Aquatic Biology. These experiences are in field and laboratory work involving fish, aquatic insects, plankton, bacteria and habitat analysis. The training programs usually include a variety of technical tasks so the students receive broad exposure to work in the aquatic sciences.

Students from several universities and

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colleges have taken advantage of the training opportunities. Some have used their experiences toward requirements for a college degree; others simply to prepare themselves for a job by applying their college 'book learning' to real world problems. From the University of Illinois, graduate and undergraduate students have crossed the Urbana campus to take part in Survey aquatic research. Many have prepared theses under the guidance of Survey scientists.

More students in recent years have come from Eastern Illinois University than from any other school. In 1972, Dr. Leonard Durham, Director of Life Sciences at EIU, established an active Environmental Biology Program and the following year included in it a requirement that each student must serve a 12-week internship in a professional environmental institution. EIU students have interned in many parts of the country and in many kinds of work with governmental and business agencies. Since the program was begun at EIU 8 years ago, 310 students have taken part in the training opportunities and 124 of these have been associated with the Survey. Many other schools in Illinois and in other states now have similar programs for their students and are sending their interns to work at the Survey.

Students are given some financial aid for their work at the Survey, but the major benefit, besides the small salary and college credits, is the improved eligibility for employment. Even a few months of professional association in biology make the student much more attractive to an employer who expects that his/her staff can face and solve present day problems. Interns from the Survey program have enjoyed spectacular job opportunities in many areas of environmental biology.

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Radar Studies of Bird Migration

For every bird which regards Illinois as its home, several others pass through this centrally located region on their way to breeding grounds. However, modern land-use practices seem to be reducing the habitats available to birds which depend upon Illinois for resting areas on their annual flights. The bottomland lakes of the Illinois River, once a prime resting and feeding habitat for ducks and other water birds, are being filled with silt eroded off agricultural fields (INHS Reports No. 200). While the land area of Illinois is certainly large, suitable habitats for many species of migrant birds are steadily disappearing, as woodlots, hedgerows, and riverbank forests give way to man's use of the land. Recent investigations by Richard Graber and Jean Graber of the Wildlife Research Section (INHS Reports No. 202) suggest that peak periods of migration may result in a "no-vacancy" situation in which small birds occupy almost all of the available forest habitat during their stopovers.

Because most species of migrating birds fly at night (the hawks, swallows, and others we see in the daytime constitute the exceptions rather than the rule), the time-tested methods of the field biologist do not

Common nocturnal migrants through Illinois, thrushes of the genus *Catharus* have been the subject of radio-tracking studies at the Illinois Natural History Survey. The distinctive thrush wing pattern may be useful in identifying them in migratory flight with radar and the tracking telescope. (Photograph by R. R. Graber)

give the full picture of avian migration. A bird seeking a hospitable place to come down often does so in the dark hours before dawn, out of reach of the sharp eyes of the field investigator.

Thus, researchers have turned to less direct methods to document the behavior of migrating birds. Chief among these is radar; even small birds can be electronically followed through the night in this way, almost certainly without their knowing that they are being tracked. In 1981 Ronald Larkin of the Wildlife Research Section will begin studies in Illinois using a radar unit which has been specially modified for use by biologists.

Some of the most basic questions about bird migration remain open, including how birds navigate from wintering to breeding grounds and back, distances often measuring thousands of miles. Other puzzles include social relations and flocking during migration — birds migrating at night are usually detected flying alone yet are often seen in flocks on stopovers.

Much of its potential for helping to answer questions like these is presently lost because radar gives almost no information on the kind of bird which is being followed. Only its general size and flight speed give clues as to the species. In a new attempt to overcome this limitation, Larkin is testing a tracking telescope and spotlight used in conjunction with radar, for the first time giving the investigator a look at the animal under study. This effort promises to pay large dividends in our basic understanding of bird migration.

The possibility that birds flying over Illinois may have difficulty finding grounds for resting and feeding is also the subject of radar investigations. Using the ability of radar to reach out over thousands of yards and track an individual bird, the researcher can study birds that are descending at the end of a night's migration and selecting a place to spend the day. Radar can also be used to count birds coming into an isolated woodlot, in order to assess the size of periodic influxes of migrants into shrinking patches of habitat.

Surprising Benefits Possible from Nonchemical Alfalfa Weevil Controls

During the past few decades several biological and cultural methods of agricultural insect pest control have been conceived. However, farmers have relied heavily on the use of synthetic chemical pesticides, largely because they achieve satisfactory control at relatively low cost. Unfortunately, the extensive use of synthetic organic pesticides has had detrimental effects on the environment.

Luis Zavaleta and William Ruesink, Survey economic entomologists, have investigated the potential benefits that might arise from the use of biological controls as well as from the introduction of a host plant with added resistance to the alfalfa weevil (*Hypera postica*). This insect is one of the more important insect pests of alfalfa and can cause significant losses in yield or even the death of the crop.

Their study used computerized models previously developed for the alfalfa crop and for the alfalfa weevil. The dynamic computer model of the alfalfa crop mimicked the daily time path of state variables, such as the biomass of leaves, stems, buds, and total nonstructural carbohydrates as a function of environmental conditions. The model simulated other conditions, such as the harvesting of the crop, its regrowth, and new material generated by photosynthesis. The rates of flow between components and the rate of photosynthesis were modeled as functions of light intensity, day lengths, temperatures, and the values of the state variables. The model assumed adequate moisture, high levels of fertility, and the absence of pest problems other than the alfalfa weevil. Dynamic computer models of the life cycles of the alfalfa weevil and the parasite (*Bathyplectes curculionis*, a small parasitic wasp which lays eggs inside weevil larvae) were also established.

Both models, the alfalfa plant growth and the insect component, were interfaced through the feeding process. The potential rate of feeding by the weevil was modeled as proportional to the average developmental rate per life stage, but this rate

varied from day to day with temperature variations. The interaction between the parasite and the weevil larvae was modeled through the process denoted attack. Through this process, a certain percentage of the larval population in the second stage was parasitized and remained so during the third and fourth stages, dying during the latter. The beneficial effects of the parasite were obtained through an induced reduction of feeding rates for the larval stages of the weevil and through an increase in its mortality rate.

For this analysis, records of 10 years were used for each of four weather stations, selected as representative of major alfalfa growing regions in the eastern United States: Ithaca, New York; Bedford, Virginia; Rochester, Minnesota; and Nashville, Illinois. For the period of analysis, daily maximum and minimum temperatures and solar radiation were required.

The model was given its initial values and set in motion as of September 1, because at that time most alfalfa weevils are diapausing adults. In the simulation runs for each locality, the initial weevil density was set at ten per square meter, typical of a moderately heavy infestation. In those cases where parasites were included, their initial density was set at two per square meter, a rather low population level for that species. These initial conditions were used in the simulation models to provide results that may be considered conservative.

Finally, the model recorded an insecticide application whenever the density of third and fourth instar weevil larvae exceeded 400 per square meter, corresponding approximately to the economic injury level recommended in Illinois.

Changes in yield, insecticide use, and their monetary values were computed by comparing 10-year averages for a normative bench-mark solution, the application of chemicals, to averages obtained for different elements integrated in pest management methods. The results thus obtained were used to measure the benefits that might be derived from integrating (a) biological and chemical controls and (b) biological, cultural, and chemical practices.

The alfalfa weevil (*Hypera postica*) can cause significant losses in yield or even the death of the crop. (Photograph by J. S. Ayars)

The researchers found that the integrated approach improved yields by reducing the damage, compared with those values reached by chemical control only, and it also reduced the amount of insecticide required.

When the data were evaluated for the eastern United States, they suggested that the parasite could save about $44 million per year as compared with the bench-mark case. This predicted increase in production represents less than 1 percent of the total crop, and it would not be expected to influence the market price for alfalfa hay. In addition, this approach could account for a great reduction in pesticide use. About 1,100 fewer tons per year of insecticide would be necessary than when only chemical control is employed. This reduction in pesticide input to the environment deserves attention far beyond its economic value, Zavaleta and Ruesink point out.

Another method of pest management is the use of cultural practices. These practices may involve, among others, adjusting the date of harvest and introducing plants that are genetically resistant to the weevil. Presently, however, no commercially available alfalfa varieties have resistance to the alfalfa weevil. Zavaleta's and Ruesink's analysis was performed to quantify the value of resistance, and the results should provide plant breeders with the incentive

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to develop varieties with even a small amount of resistance.

The type of resistance considered here is known as antibiosis, in which some characteristic of the plant causes a reduction in the survival of the pest population. Specifically, 20-, 40-, 60-, and 100-percent additional mortality levels were evaluated.

The use of a truly resistant plant — one on which the pest can not (or will not) live, represented here by the 100-percent added mortality case — would increase average yields to a total value of $89 million per year. At the same time, insecticide use would be reduced to zero.

If breeders achieved only 60-percent added larval mortality, insecticide use still would decline to zero, but a small amount of damage to alfalfa would continue to occur. Under these conditions the damage is too slight to justify the expense of insecticide application. Thus, 60-percent added mortality would be nearly as beneficial as 100 percent.

If 40-percent added mortality were attained, the value of production would increase by $61 million per year, and insecticide use would decrease by 3,743 tons annually. In this case, some insecticide would still be used in the Midwest, but the use rate would be 85 percent below the present rate. East of the Allegheny Mountains, because of differences in the eastern and western weevil populations, no insecticide would be needed.

Finally, if only 20-percent mortality were added to the first larval instar, the value of production in the eastern United States could be increased by $30 million per year, and annual insecticide use could decrease by 2,260 tons. Although these figures are far inferior to those of the 40-percent case, producers and environmentalists would welcome this dramatic improvement.

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Paul G. Risser, Appointed Chief of the Survey

Dr. Paul G. Risser has been appointed Chief of the Natural History Survey by the Board of Natural Resources and Conservation. He currently is Chairman of the Department of Botany and Microbiology, University of Oklahoma. Risser officially will assume his new administrative responsibilities on June 1, 1981, and will succeed Dr. George Sprugel, Jr., who retired on August 30 last year. During the interim, Dr. Wallace E. LaBerge has served as Acting Chief.

Risser's selection by the Board followed a thorough screening process by the Staff Search Committee that examined and interviewed qualified applicants from the USA and Canada (see October 1980 issue of **Natural History Survey Reports**). The formal announcement was made by Director Frank Beal of the Illinois Institute of Natural Resources who serves as the Board's chairman.

Dr. Paul G. Risser, new Survey Chief. (Photo by Les Woodrum, Survey Photographer)

The new Chief will bring to the Survey an immense wealth of administrative experience and proven leadership in the areas of environmental research and survey related activities. Prior to the appointment as chairman of his department at the University of Oklahoma in 1978, Risser served as Program Director of Ecosystem Studies for the National Science Foundation, Director of the Oklahoma Biological Survey, and Assistant Director of the Oklahoma Biological Station. One of his colleagues remarked that he brought national recognition to the Oklahoma Biological Survey by turning it into a viable program for the State of Oklahoma.

As a leader in environmental biology and plant ecology he has participated on various national and international committees and delegations. His national associations have been with the National Science Foundation, Smithsonian Institution, Interagency Federal Committee on Ecological Reserves, and the U.S. Fish and Wildlife Service. Internationally he has been involved with the International Biological Program, a U.S. delegation to the Soviet Union for discussions of biosphere

reserves and ecosystem analyses; and various meetings in France and Switzerland under the auspices of UNESCO, UNEP, and IUCN.

Risser is a graduate of the University of Wisconsin where he was awarded a PhD in Botany in 1967. His productive scientific career as a plant ecologist has centered on the analysis of plant communities and the assessment of environmental changes on plant ecoystems. As Chief of the Survey he is planning to maintain an active research program in addition to administering the diverse programs of the Survey. This will take considerable effort but as one observer noted, Risser has a great capacity for organization and work.

Risser applied for the position of Chief because of the highly regarded national reputation of the Survey and its programs. He considers the Survey to be the finest institution of its type and welcomes the association with it and its high quality research endeavors which, he stated, coincide with his own scientific and intellectual interests.

The staff of the Survey is very supportive of Risser's appointment as Chief and is anticipating a productive and stimulating association with him.

Clams of the Vermilion River System

The freshwater mussel (clam) fauna in eastern North America is the richest in the world; approximately half of the known species of freshwater mussels occur in this defined geographical region. The quantity of mussels found in rivers from Wisconsin to Alabama is equalled almost nowhere else in the world.

Mussels are a unique source of commercial and aesthetic value. Their shells are used as the basic raw material in the production of cultured pearls in Japan. Several species are very sensitive to changes in water quality and serve as valuable indicators of environmental changes.

In Illinois, a variety of aquatic habitats support a diverse and abundant mussel fauna. However, recent surveys indicate that serious depletions of both numbers of individuals and species of mussels are occurring in Illinois. John Suloway, a member of the Section of Aquatic Biology, and Liane Suloway, a member of the Section of Faunistic Surveys and Insect Identification, have been contracted by the Illinois Department of Conservation to determine the status of mussels in the Vermilion River system (Wabash River basin) in eastern Illinois.

The major objectives of the study are (1) to determine the number of individuals and number of species of mussels at approximately 30 sites in the Vermilion River system, (2) to compare this data with historical information, (3) to correlate the changes in mussel communities with changes in substrate and water quality, and (4) to aid the Department of Conserva-

Quadrula cylindrica, also called the rabbit's foot, a rare mussel (clam) found in the Vermilion River in eastern Illinois. (Photo by Les Woodrum, Survey Photographer)

tion in the establishment of criteria for natural areas in Illinois.

Twenty-two species of mussels were collected in 1980. The North Fork at present supports the highest densities and diversities of mussels in the Vermilion River system. Several species collected in 1980 are uncommon in Illinois, and at least two of these species, *Obovaria subrotunda* and *Quadrula cylindrica,* are restricted to the Ohio River basin in Illinois. *Quadrula cylindrica* is considered rare and endangered in the U.S.A. by some experts.

Thirty-two species of mussels have been found in the Vermilion River system since the turn of the century. Between 1960 and 1980, the number of species collected declined from 25 to 22 with a concurrent 61 percent reduction in number of individuals collected.

This investigation will be completed by July 1, 1981. During the spring of 1981, collections will be made at approximately six additional stations. The entire data base of chemical, physical and biological results will be analyzed and synthesized in the final report to the Department of Conservation.

Aphid Nose Knows

Did you ever wonder exactly how those aphids managed to find your favorite rose bush or get into your house and find that prized plant and what that might have to do with an aphid's "nose"?

Most aphids are rather fussy feeders and to accommodate this fussiness they have evolved some complex behavior and developmental patterns. Let's look at the common aphid on rose, *Macrosiphum rosae.* That rose bush in your front yard was completely free of aphids after you sprayed it last year but by mid-June of this year it will be covered with aphids again. Where did they come from and how did they get to your rose? They came from another, perhaps distant, rose somewhere. During the winter months this species survives as eggs laid on the stems of rose bushes. The hatch will be from early April in southern Illinois to late April in the northern part of the state. This generation, called the fundatrices, will mature in about two weeks and almost immediately will begin giving birth to live aphids which will grow and reach maturity in another two weeks. These generations are wingless and confined to the host plant. It doesn't take long for the original rose plant to become very crowded, especially after two or three generations. Crowding does interesting things to aphids and plants. Under heavy feeding pressure from the aphids, the plant may become very weakened, wilt and die. The aphids can sense this, possibly through the quality of the sap they are sucking from the plant, and they can also detect their crowded living conditions. In response to one or both of these stimuli the next generation develops wings.

Apterous viviparae (wingless adults that give birth to live nymphs) and nymphs of the rose aphid, *Macrosiphum rosae,* on cultivated rose. (Photo by David Voegtlin, Assistant Taxonomist)

When the winged forms are fully developed, other roses become fair game. These winged aphids leave their crowded, dying home, fly up and are carried away by the wind. They will continue to fly until some physiological demand is satisfied and then will slowly descend toward the ground. The amount of time spent in the air will vary from less than an hour to an entire day. With a moderate wind speed a considerable distance may be covered. As the aphids near the ground they will have a variety of plants to land on. They may in fact have landed in the middle of a

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square mile of corn or soybeans, and our fussy rose aphid absolutely refuses to feed on these plants. How does it know they aren't roses. The nose — we finally got back to the nose — will tell them.

Aphids can't see very well, and although they are quite good at colors they seem to rely on close-up taste tests for final judgment. After landing from an extended flight, the aphid will place its rostrum (nose) against the plant surface, and from this rostrum tiny stylets will probe the plant and taste it. There are sensors on the tip of the rostrum and quite possibly some associated with the stylets. Positive or negative stimuli will trigger further responses. If there are negative stimuli our aphid will launch itself again and again until it finds a rose. There is usually a tremendous mortality to aphids during this time, but there are always a few who happen to find the preferred host, your rose bush, well fertilized, with swollen flower buds and a veritable aphid feast.

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Pheasant Nest Habitat Along Rural Roads

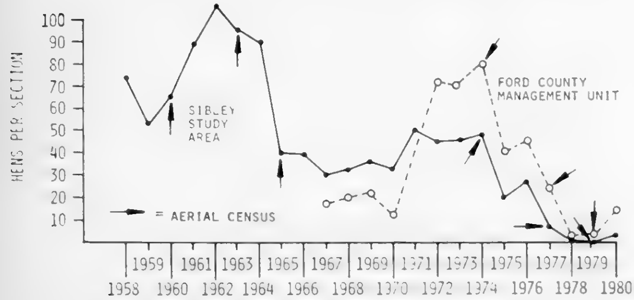
From 1962 to 1977 changes in agricultural land use in Illinois pheasant range resulted in the loss of approximately 54 percent (2.4 million acres) of the hay and small-grain acreages and 45 percent (1.8 million acres) of uncultivated farmland to row-crop production. In addition, during this period approximately 2 million acres of farmland were converted to nonagricultural uses in the counties that sustain self-maintaining populations of pheasants — the northern two-thirds of Illinois.

The loss of habitat for reproduction and the clean farming practices associated with row-crop production have been almost cataclysmic developments for pheasants and native ground-nesting wildlife.

Wildlife biologist Richard E. Warner has been evaluating roadside management by the Department of Conservation (DOC) in east-central Illinois as a program that may in part mitigate the loss of nest habitat. The Ford County Management Unit (FCMU) was established in 1968; 61 of the 65 farmers on the 20-square-mile area allowed the DOC to establish a combination of bromegrass and alfalfa along roadsides and agreed to delay mowing annually until August 1.

Nest studies conducted on the FCMU since 1973 have indicated that more than half of the juvenile pheasants recruited into the fall population typically hatch in developed roadside vegetation. Late winter and spring indices of relative abundance suggest that when the roadside vegetation became established after 1970, the numbers of ringnecks on the FCMU increased substantially over those of the premanagement era (1967–1970). Moreover, since approximately 1971, pheasants have been more abundant on the FCMU than on the reference area near Sibley.

Although pheasant populations on the FCMU have maintained a margin of abundance over those of the reference area, roadside management has not mitigated the deleterious effects of intensified agriculture in the 1970's or the decimation of



The relative abundance of hen pheasants on the Ford County Management Unit and the nearby Sibley Study Area.

ringneck populations by winter storms in January 1977 and during the winter of 1977–1978. However, censuses conducted in 1980 indicate that recovery from recent storm-related declines may be enhanced by roadside management.

Although most research on the FCMU has been directed toward pheasants, nest studies have also encompassed ground-nesting songbirds. Preliminary analyses indicate that these species have responded to roadside management in a manner similar to that documented for ringneck populations.

Mississippi Navigation Effects on Macroinvertebrates

One of the major tasks of a research effort to determine the effects of navigation on the aquatic resources of the Mississippi River got off to an enthusiastic start this past summer. Dick Seagle and Jeff Hutton, Survey aquatic biologists, and Rick Anderson and Deborah Leibig of Western Illinois University began work to determine the effects of river navigation on the drift of aquatic insects and other small organisms, collectively referred to as macroinvertebrates. The first phase of the study, which began in June, involved selecting representative sampling sites and testing field methods and gear.

Pool 26, located near Alton, Illinois, is where the Illinois River enters the Mississippi. Of the commercial river traffic passing through Pool 26, about 60 percent moves down the Illinois River, and about 40 percent comes down the Mississippi above the Illinois confluence. Thus, Pool 26 offered the unique opportunity to study the effects of different levels of barge traffic on aquatic resources in a single pool. Based on physical similarity, three sites, corresponding to the three levels of traffic, were chosen for intensive biological sampling: sites 1 and 2, Mississippi River miles 211.5 and 219.7; site 3, Illinois River mile 3.

The second phase of the summer's work was to describe the distribution, abundance, and drift rates of aquatic macroinvertebrates at the three sites and to establish a base of information from which to work. Drift, a natural phenomenon, is defined as the entry into the water column and the downstream movement of invertebrates. Most aquatic invertebrates exhibit some sort of drift periodicity, and some groups, e.g., mayflies, flies, and caddisflies, occur in extremely high numbers at night. Drift is important in the aquatic ecosystem because it regulates invertebrate populations, supplies organisms to recolonize stressed areas, and is an important food source for fish and other aquatic species. One of the reasons for including drift research in a navigation-effects study is that barges and large pleasure craft can vastly alter water pressure and velocity when they pass a certain point in the river. It has been hypothesized that these pressure and velocity changes are great enough to dislodge organisms from the substrate, thus inducing drift. Induced drift and altered drift rates could seriously affect invertebrate populations and the species that depend on them for food.

The macroinvertebrate community was sampled with a ponar dredge, artificial substrates (rock-filled baskets placed on the river bottom), and "bongo" drift nets. Though the usual substrates in the Illinois River (silt-clay) and Mississippi River (sand) are different, ponar samples indicated small standing crops of macroinvertebrates and few species in both systems. The average number of specimens per dredge sample for both rivers was generally less than 20, and the average number of species never exceeded five. The macroinvertebrate community in the Mississippi River was dominated by midges, caddisflies, mayflies, and worms. Dominant forms in the Illinois River were worms and midges.

Artificial substrates in the Mississippi River were placed on wing dams (submerged rock dikes extending into the channel to train the river flow). These areas provide a good substrate for colonization, typically exhibit high macroinvertebrate productivity, and are likely to be affected by water pressure and velocity changes generated by barges. Artificial substrates in the Mississippi River had by far the greatest average number of specimens (2,421) and the highest average of species (16) of macroinvertebrates. Illinois River

Natural History Survey researchers are attempting to learn how towboats (like this one on the Illinois River at Beardstown) affect the drift of aquatic insects and other small organisms. (Photo from a slide by W. C. Starrett)

artificial substrates were subjected to heavy siltation and averaged only 291 animals and six species.

The number of species and animals collected per unit of time in drift-net samples was lowest at Mississippi River mile 211.5. The other drift-net sampling sites (Illinois River mile 3 and Mississippi River mile 219.7) produced at least twice the number of animals and more species. Drift-net samples taken off the two types of substrates (sand-silt and rock) were similar in the Illinois River. Phantom midges dominated the samples, and at times net-spinning caddisflies, mayflies, and hydra were common. Drift-net samples off of wing dams at both Mississippi River sites were somewhat similar to one another. Phantom midges, net-spinning caddisflies, mayflies, and hydra were the dominant forms. Sand-silt substrate drift was dominated by mayflies, hydra, and phantom midges. Drift densities (number per cubic meter) at all sites were always higher at night than in the day, and highest drift densities were recorded at 1:00 and 4:30 a.m.

Air Pollution and Illinois Agriculture

Many people are increasingly concerned about the variety, quantity, and pervasiveness of materials which are added to the environment. These include gases, particulates, agricultural chemicals, and radioactive materials added to the atmosphere; sewage and chemicals to water systems; and solid wastes to the land. Environmental pollutants, acting individually and together, affect man's food supply, health, and well-being, sometimes adversely. Indeed, clean air is not the normal environment for plant and animal growth in many locations. Air pollution, or "smog," is usually identified with large metropolitan areas, such as New York, Chicago, Denver, and Los Angeles. However, scientists are aware of and often disturbed by the apparent increase of air pollutants in nonmetropolitan and rural areas whose economic base is frequently agricultural.

Growing plants, whether in a garden, ornamental landscape, or agricultural field, exist simultaneously in both air and soil environments and are particularly susceptible to environmental pollution. Vegetation is especially important because light energy is captured and transformed to chemical energy by photosynthesis. As a result of this activity, plants are pivotal for food production and the support of food webs.

For some time, environmental quality

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has been a major interest of Natural History Survey scientists, who conduct research on the renewable natural resources of the state. The Survey's participation in environmental studies has been broadened to include plant-air pollution interactions. Anton G. Endress of the Botany and Plant Pathology Section is constructing a chamber system to examine the effects of exposure to air pollutants on the development, growth, yield, and quality of plants. These studies emphasize the acidic gaseous pollutants — sulfur dioxide (SO_2), nitrogen oxides (NO_x), and hydrogen chloride (HCl) — which are produced by the burning of coal or refuse for heat and power needs. There are indications that the concentrations in the air of certain pollutants will increase in the future mainly due to the combined pressures for relaxation of air-quality standards and the increased use of domestic coal.

Endress and two colleagues, Claus Grunwald and Donald F. Schoeneweiss, are currently initiating a study of soybean growth and development as it is affected by SO_2. Soybeans were chosen because Illinois is the U.S. leader in soybean production, and several studies have shown that soybeans are sensitive to air quality.

The Survey scientists emphasize that injury to vegetation was one of the earliest manifestations of air pollution and has been a subject of study for over a century. Most studies have concentrated on injury symptoms of leaves, which consist of various types of pigmented, chlorotic, or necrotic markings. Growth and yield reductions caused by air pollutants have also been known for some time and are recognized as widespread problems. Yield losses have occurred when leaves showed visible markings. In the last few years, however, yield losses from air pollutants have been reported without any visible injury to the crop. For example, last year scientists from the Argonne National Laboratory in northern Illinois reported soybean yield losses ranging from 5 to 48 percent even though no injury symptoms were observed on the plants. They used SO_2 in their experiments, but because these were field studies, the participation of other unknown airborne substances could not be ruled out. The yield reductions stemmed mainly from lower seed weights and fewer seeds per plant.

Botanist Endress and his colleagues are initiating their studies in an attempt to verify the observations of the Argonne group. They are also concerned with altered seed quality, which may restrict the dietary or industrial use of soybeans, and air pollutant stress, which may reduce soybean plant vigor, rendering them more susceptible to pathogens.

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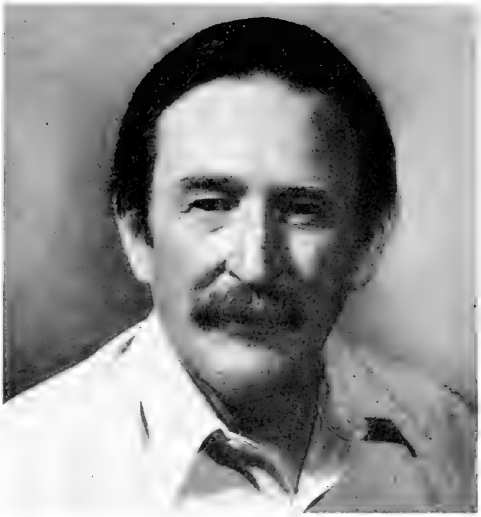
Homer's Odyssey to China

Homer Buck, Survey aquatic biologist, recently returned from the People's Republic of China where he served as an invited consultant for the development of expanding aquaculture programs. His trip was sponsored by the Food and Agriculture Organization of the United Nations (UNFAO). This article is a summary of his travels and observations.

One of the great challenges of our age is to increase the production of food in Asia, Africa, and other developing areas. The food most desperately needed by millions of hungry people is animal protein, and one of the most efficient ways to produce the protein is through aquaculture. Of the programs now in operation, or under development, one of the newest and most promising is the Asian Network of Aquaculture Centers.



Dr. Homer Buck, Survey Aquatic Biologist (Photo by Les Woodrum, Survey Photographer).

UNFAO through its United Nations Development Program (UNDP), in concert with various host governments, recently has completed centers in India, Thailand, and the Philippines. These centers have elaborate facilities, and are well funded and well staffed for two principal purposes: (1) to develop and/or improve the technologies that offer greatest potential for the efficient, high-volume production of fishes, prawns, and other forms of aquatic protein: and (2) to train technologists and potential aquaculturists to apply the technologies that are developed. A fourth Asian center, and potentially the most important, is nearing completion at Wuxi (near Shanghai), People's Republic of China. It will be known as the Regional Lead Center for Integrated Fish Farming. Its special importance derives from two auxiliary purposes: (1) the training of technologists from other developing countries and (2) the extension of Chinese technologies on a global basis.

The traditional Chinese system involves an almost total integration of agriculture and aquaculture. For example, in areas where fish production is the primary function, the production goals for all other agriculture commodities are geared to the quota that was established first for fish production: and labor, land, water, and other resources are apportioned accordingly. The Chinese system has manures, vegetable tops, green fodder, etc., all entering fish

ponds in either a fresh, fermented or composted form; and the organically enriched silt is removed annually from the pond bottoms and returned to the land as fertilizer. While this ancient system is unquestionably successful, there has been surprisingly little analysis or documentation of how or why it works, or of which elements of the system are the most important or efficient. It also is recognized that the systems of integration as practiced in China will have to be modified to meet the needs, climate, and resources of other areas.

The Chinese system is not unknown in Illinois. Since 1975 the research program at the INHS field station at Kinmundy has included studies of the application of certain Chinese methods to our midwestern agricultural systems. This has been done because we in time will need to maximize the use of our diminishing resources. As a result of the Kinmundy studies, Buck, of the Kinmundy staff, was invited to China to participate in the development of the program of research for the new Chinese center. Additional members of the task force included (1) a second consultant, Gerald L. Schroeder, who has conducted extensive research in manured fish ponds in Israel; (2) T. V. R. Pillay, Chief Administrator of Aquaculture Development in the Rome headquarters of the UNFAO; and (3) Chen Foo-Yan, Project Coordinator for the UNDP Network of Aquaculture Centers in Asia, headquartered in Bangkok. Following initial briefings and a good measure of hospitality from Chinese officials in Peking, the task force travelled by train approximately 1,000 km south of the site of the new center at Wuxi to meet with Chinese counterparts. A second flurry of briefings and festivities was followed by nine consecutive, very intensive days of discussions, writing, and translation, followed by more discussions, writing, etc., broken only by a one-day excursion to two local communes. The meetings were extremely cordial and stimulating.

The final product was a documentary draft outlining 16 specific areas of research to be addressed over an initial 7-year period. Five of the 16 specific points of investigation are listed as examples.

1. Comparative studies on the effects of fresh and fermented animal manure on fish yields.
2. Comparative studies on the performance of different livestock manures in relation to fish production.
3. Studies on the relative values of green manure and animal manure on fish production.
4. Water quality and pond dynamics studies for establishing an upper limit of manure quantum which could be "safely" added to fish ponds under different environmental conditions.
5. Comparative studies on the economics of dual and multiple integration of crops aimed at establishing models for various integrated farming systems.

It is believed that critical examination of the Chinese systems and procedures will yield short-term benefits to China and to other developing countries, and will in time prove useful in Illinois.

Putting the Heat on Horseradish Disease

Illinois, well noted for its soybean and corn production, is the leader in yet another agricultural crop — horseradish. This crucifer, grown for its fleshy pungent roots ground for use as a condiment, is produced on about 1,000 acres in Madison and St. Clair counties near East St. Louis, an area which provides half to two-thirds of the nation's harvest.

Since the mid-1930's Illinois horseradish periodically has been devastated by outbreaks of brittleroot, a condition resulting in yellowing of the foliage, stunting, occasional wilting, reduction in the number of branch roots, discoloration of the root phloem, brittleness of the root, and plant death or severe reduction in quality of harvested roots. Whether the condition was a result of infection by plant pathogenic organisms, mineral imbalance in the soil, or adverse environmental conditions previously was not known.

After a brittleroot epidemic destroyed 60 percent of the Illinois crop in 1979, an in-

Patch of brittleroot-affected horseradish (pale, center plants) (Photo by Survey Entomologist Dan Sherrod).

terdisciplinary team of researchers was put together by W. H. Luckmann of the Economic Entomology Section of the Illinois Natural History Survey and R. E. Ford of the University of Illinois, Department of Plant Pathology. With support from the Illinois Agricultural Experiment Station and the State of Illinois, this team set out to determine the causal agent(s) of brittleroot and its epidemiology. Natural History Survey and University of Illinois entomologists Jerry Schultz, Cathy Eastman, Mickey McGuire, and Karen O'Hayer joined plant pathologists Jacque Fletcher, Robert Goodman, and Kathy Franklin in this pursuit. Additional expertise was provided by consultants in plant pathology, horticulture, and agronomy at the University of Illinois and by research cooperators at the USDA Plant Virology Laboratory in Beltsville, MD, the Division of Biological Sciences at the University of California at Davis, and the USDA Agricultural Research Station in Salinas, CA.

Although soil fertility and environmental conditions were possible factors in the development of brittleroot outbreaks, the working hypothesis receiving the most support was that brittleroot was a result of the infection of previously healthy horseradish with one or more insect-transmitted pathogenic organisms. Since brittleroot epidemics have occurred at highly irregular intervals, some means had to be found to produce a dependable supply of plants with fresh infections as a source of experimental material. Numerous attempts were made early in the project to produce brittleroot-like symptoms in healthy horseradish by confining these test plants with selected leafhopper and aphid species which had fed previously on diseased horseradish collected from the field during the 1979 outbreak. In two instances brittleroot-like symptoms were produced in test plants, but evaluation of these results was hampered by lack of a critical means of determining differences in the organisms present in test versus control plants.

A major breakthrough occurred in 1980 with the report from research cooperators at the University of California-Davis that bacteria-like organisms had been seen with the electron microscope in thin-section samples from a diseased horseradish plant obtained from Illinois but were not present in samples from a healthy plant. With this lead and with the help of plant pathologists at Beltsville, MD, researchers here were able to culture a small helical bacterium called a spiroplasma and determine that it is **Spiroplasma citri,** known to cause a serious disease of citrus in California and Arizona. This was indeed a surprise because it was the first documented report of the existence of **S. citri** in the U.S. east of Arizona. Subsequently the spiroplasma was isolated and cultured from numerous diseased horseradish plants collected from the 1980 Illinois horseradish crop but was never present in healthy horseradish plant samples.

Armed at last with a reliable method for evaluating laboratory experiments, the research team was then able to test the hypothesis that **S. citri** was the primary

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cause of brittleroot. Plant pathogenic spiroplasmas are known to be transmitted primarily by leafhoppers. The beet leafhopper (**Circulifer tenellus**) was chosen as a test vector because this desert-loving insect is known to transmit **S. citri** to citrus in California and has been collected in Illinois horseradish during some past brittleroot epidemics. These leafhoppers were microinjected with small hand-drawn glass needles containing cultured preparations of **S. citri** previously isolated from diseased horseradish. After the insects were allowed to feed on healthy horseradish some of these horseradish test plants developed brittleroot-like symptoms. **S. citri** was reisolated from the test plants and was not present in control plants, which remained symptomless. In separate tests beet leafhoppers were able to acquire **S. citri** naturally by feeding on diseased horseradish and to transmit the spiroplasma to healthy test horseradish, which then developed brittleroot-like symptoms.

The finding of an association between this spiroplasma and brittleroot of horseradish is only the second instance in which an important plant disease of unknown etiology has been shown to be caused by **S. citri.** Horseradish is also a new addition to the list of reported hosts for this organism.

Work is underway to develop a control program for brittleroot. Other pathogens, especially viruses, known to occur with varying frequency in Illinois horseradish are being checked to determine if they help or hinder subsequent infection of horseradish with the spiroplasma. Selected plant species reported to be susceptible to California-Arizona isolates of **S. citri** are being tested for their susceptibility to isolates from Illinois horseradish to see if they are similar in pathogenicity; to date the team has succeeded in producing infections in periwinkle, turnip, radish, and aster. Weeds, especially crucifers, common in the horseradish production area are also being examined to determine their susceptibility to **S. citri** and, thus, their potential role in brittleroot epidemics. Presently wild mustard, shepherd's purse, and yellow rocket have been infected experimentally with **S. citri.** Although Illinois researchers have shown the beet leafhopper to transmit the spiroplasm to horseradish under experimental conditions, the field vectors for brittleroot outbreaks have not yet been determined; therefore, other leafhopper species common in Illinois horseradish fields are being examined as well for their ability to transmit **S. citri.** Research is being done on how quickly and efficiently the beet leafhopper can transmit the spiroplasma. This information will be important in determining if insecticides will be sufficient to control the leafhoppers and, thus, brittleroot outbreaks.

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Air Traffic Control for Soybean Aphids

Air traffic controllers have been much in the news recently, but did you know that it may be possible to use a form of air traffic control of flying aphids to help reduce the spread of soybean mosaic virus?

It is known that soybean mosaic virus is spread within fields by flying aphids. Consequently, a potential means of reducing the spread of this disease is to modify the landing behavior of the disease-carrying aphids — to make a field unattractive to aphids so that they will not land in it.

Survey economic entomologists Susan Halbert and Michael Irwin knew that earlier researchers had obtained contradictory and inconclusive evidence as to whether differences in the percentage of ground cover influenced aphid landing behavior. They decided to determine the differences in the numbers and species of aphids that are likely to land in soybean fields planted in narrow or wide rows.

The entomologists placed 10 sticky traps designed to catch insects in each of two soybean fields. The distance between rows in one field was 7 inches and in the other it was 30 inches. The experiment was conducted for two growing seasons at the Vegetable Crops Experimental Farm of the University of Illinois. Aphid trapping began on June 11 of the first year and on June 27 in the second year. The leaf canopy of the narrow-row field was closed after the second week of sampling in both years, and during the entire experiment the narrow planting had a higher percentage of ground cover than had the wide one. Aphid trapping was stopped when the canopy closed over the wide-row field, after 35 days in the first year and after 32 days in the second.

The sticky traps were ermine-lime colored ceramic tiles. The color was designed to approximate the color of soybean foliage that is attractive to aphids. The tiles were mounted on ring stands that were, in turn, mounted on steel rods driven into the soil. As the soybeans grew, the tiles were raised and were continually maintained at canopy level.

The entomologists found no statistically significant difference in the total numbers of aphids trapped in the two fields. However, the flying aphids *Aphis citricola* and *Myzocallis punctatus* were caught in significantly greater numbers on traps in the narrow-row field. The species *Capitophorus elaeagni* was collected more abundantly on traps in the wide-row field during the first 2 weeks of the season. That trend was apparent during the remainder of the season, but the difference was not statistically significant; the difference for season totals, however, was highly significant. *Lipaphis erysimi, Rhopalosiphum maidis,* and *Schizaphis graminum,* the three additional species collected in large enough numbers for statistical analysis, exhibited no preferences between the open and closed canopies of wide and narrow plantings.

Of the three aphid species that showed significant preferences, *C. elaeagni* and *A. citricola* have been found capable of transmitting soybean mosaic virus.

The preference for an open or closed

canopy seems to vary among species. Therefore, the possibility of restricting the spread of soybean mosaic virus by adjusting row spacing depends on which species of aphids are locally important.

Of the aphids that responded to ground cover variation, *A. citricola* was collected in greater numbers over continuous cover during weeks 3–5, while *C. elaeagni* was collected in greater numbers over wide rows during weeks 1–2 (and probably during weeks 3–5). Thus, response by flying aphids to ground cover depends on species and time of year. Seed transmission of soybean mosaic virus, one of the most important economic aspects of the disease, is more likely if parent plants are infected early in the growing season. This fact focuses attention on the importance of early season disease-carrying aphids. The early part of the season is also the time when row spacing has the greatest effect on ground cover. Row spacing might be used as a means of limiting the spread of soybean mosaic virus that results in seed transmission if the principal spring and early summer aphids were responsive to ground cover variation.

The entomologists point out that there is no evidence to indicate that manipulation of the percentage of ground cover would eliminate aphid landings and therefore eliminate the spread of soybean mosaic virus. However, depending upon the aphid species involved, it could reduce aphid landings enough to make the practice useful as part of an integrated pest management program to control soybean mosaic virus.

Choosing the Transplanting Season

Survey plant pathologist E. B. Himelick provides this information about tree and shrub transplanting in various seasons (taken from a manual recently published by the International Society of Aboriculture).

The time of year in which transplanting must occur is not always in the control of the planter. Economic or weather conditions may determine a plant's availability. Landscaping may be required immediately upon completion of building construction. Unavailable equipment or labor may delay the planting program. Fortunately, experienced plantsmen using properly prepared plants can successfully transplant most trees and shrubs in any season. The growing of plants in containers has also helped ease the seasonal requirements for transplanting. This is especially true when small shrubs and trees are used in the landscape plan.

The opinions of qualified nurserymen and arborists vary concerning the most satisfactory time for transplanting trees and shrubs. Climatic conditions that vary with locality and year will influence both planting time and planting practices. Plant species and method of digging will also influence season for transplanting.

In general, deciduous plants are preferably planted in the fall after leaf drop and before the soil freezes or in early spring before budbreak. Many tree species may be planted in winter when the soil ball is frozen. The frozen ball must be protected to prevent root damage. Some plant species have a limited tolerance to soil temperatures below 25°F. Narrow-leaved evergreens may be planted in the fall or in the spring before the start of new growth. Broadleaved evergreens are usually transplanted in the spring.

Important factors involved in selecting the planting season are: a) soil moisture and temperature, b) exposure, c) the growth stage of plant, d) plant hardiness, and e) the inherent nature of the species.

Fall planting has the advantages of favorable soil temperature, usually adequate moisture, and time for some root regeneration before the following spring. Winter planting in cold climates has few advantages other than what may be termed operative. It takes advantage of the normal slack period of the plantsman and may permit the use of a frozen soil ball, thus requiring less time for balling and burlapping.

Spring planting has the advantage of ample soil moisture and overcomes the possibility that sufficient roots may not become established before freezing weather. Summer planting has the advantages of timeliness and favorable soil temperature, although soil moisture may need to be supplemented through irrigation. Transplant-

This large tree spade digs a soil ball 7 feet in diameter weighing about 4 tons, and it is capable of transplanting trees with trunks 6–8 inches in diameter. (Photo courtesy of Vermeer Manufacturing Co.)

ing should be avoided during spring and summer periods when there is rapid leaf growth. It is essential to wait until after the early rapid spring growth has slowed before moving trees in full leaf.

A hardening-off period is frequently given plants before moving to the planting site. This consists of holding plants in a cool, moist place for 1 or 2 days. This will aid in successful late spring and summer transplanting. All plants transplanted in leaf should be moved with a ball of soil. Shipment of plants during the hot summer for long distances can result in severe plant injury. Transplanting operations during the summer should be carried out by experienced arborists, nurserymen, or landscape contractors who will guarantee plant survival.

The History of Illinois Valley Lakes

Several studies have been undertaken recently by the Natural History Survey for the Chicago District, U.S. Army Corps of Engineers. These studies have concerned the effect of the Illinois River's 9-foot waterway on fish and wildlife and the potential effect of a projected increase in water diverted from Lake Michigan. A spin-off of these contract studies was the collection of data on physical parameters of bottomland lakes that relate to their history and to their future for fish and wildlife.

The Illinois Valley has been famous for its waterfowl hunting as far back as the 1880's. During the early 1900's, its commercial fish yield was the largest of any river except the Columbia. The favorable habitat for fish and wildlife was created primarily by bottomland lakes that are associated with the narrow, straight river channel.

The bottomland lakes have undergone many changes since 1900. Wildlife specialists Frank C. Bellrose, Stephen P. Havera, and H. Kathleen Archer are preparing a report about these changes. The first major

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change occurred in the early 1900's as river levels rose as the result of water diverted from Lake Michigan. The increased water levels resulted in a doubling of the surface area of lakes associated with the Illinois River. Under pristine conditions, there were 33,936 acres of surface area in bottomland lakes; this area increased to 67,693 acres as a result of diverted water.

Prior to this diversion, only four lakes were over 1,600 acres, mostly in the valley above Beardstown. The surface area of many bottomland sloughs, ponds, and lakes coalesced to form larger areas. Currently, even with drainage and levee districts eliminating about half of the bottomland lakes, there are 11 lakes of over 1,600 acres.

Shortly after the diversion increased lake areas, drainage and levee districts began to whittle away at the area of bottomland lakes in the Illinois Valley. Before the levee-district era ended in the early 1920's, 184,742 acres of bottomland had been enclosed by levees, eliminating a calculated 21,725 acres of water surface.

As demonstrated by studies made by the Natural History Survey and by the State Water Survey, sedimentation of the remaining water areas in the Illinois Valley provides the gravest threat to their existence. A Natural History Survey Bulletin reported on the sedimentation rate for a number of bottomland lakes (INHS Bulletin 32[1]) in the Illinois Valley. Since then, additional studies of sedimentation rates have been made. These studies include Clear, Big, Matanzas, and Grand Island lakes in the La Grange Navigation Pool and Swan Lake (near Grafton) in the Alton Navigation Pool. The later findings on sedimentation rates substantiate those made earlier.

In the earlier report it was pointed out that sedimentation rates varied linearly with water depth, the deep areas filling much more rapidly than shallow ones. As a consequence, the basins of most bottomland lakes are saucer shaped and shallow. The mean water depth of all sampled lakes was 2 feet. Upper Peoria Lake is the deepest, with a mean depth of 3.2 feet.

At the 1-meter (1.1 yards) water depth, bottomland lakes are filling with sediment at rates that vary from 0.5 to 1 cm (0.2 to 0.4 inch) per year. Upper Peoria Lake is filling with sediments at a faster rate than any other lake — nearly 2 cm (0.8 inch) per year. The projected half-life of Illinois Valley lakes is quite short — 24–230 years. By the time the half-life is reached, those lakes will be too shallow to provide sufficient water for fishing and boating and will provide for only limited waterfowl hunting.

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New Pine Disease

My pine trees are dying. Today this is a common statement made by many Illinois homemakers, foresters, nurserymen, and Christmas tree growers. Dead pine trees are evident along highway plantings, parks, home landscapes, and commercial plantations throughout the Midwest. A given pine tree may appear healthy but six weeks later the entire tree may turn brown and die. The pinewood nematode, *Bursaphelenchus xylophilus,* and an associated blue stain fungus, *Ceratocystis* sp., appear to be the causal agents in the pine deaths. Scotch and Austrian pines are the most susceptible in Illinois, but it has been recorded from red, jack, Virginia, and white pine.

The pinewood nematode was discovered in Japan in 1913. Currently the nematode is occurring in epidemic proportions in Japan, where it has infested 1,250,000 acres of pines. The first United States discovery of the nematode in Scotch pine occurred in 1979 in Missouri. There have

Scotch pine tree killed by pinewood nematode-blue stain fungus disease. All needles on this tree were brown. Note needle loss on lower half of the tree (Photo by J. E. Appleby).

Monochamus carolinensis, vector of the pinewood nematode, feeding on a pine tree (Photo by J. E. Appleby).

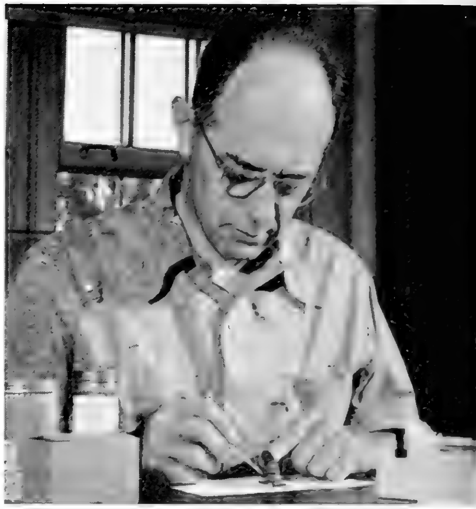
been confirmed reports of the nematode in 38 Illinois counties.

Japanese scientists have reported that the nematode is transferred from tree to tree by several species of longhorned beetles. When nematode-carrying beetles feed on healthy pine trees, the nematodes leave the beetles' bodies and enter the trees through the feeding wounds. Once a tree is infected the nematodes increase in numbers at an alarming rate. The tree can be infected in early summer and be dead three months later.

The longhorned beetle, *Monochamus carolinensis*, is a common pine borer found in Illinois and is a pinewood nematode vector. The adult beetle measures 20-25 mm in length. Within the breathing pores (spiracles) of a single adult beetle, thousands of nematodes have been found. The female beetles deposit their eggs on a dead or dying pine tree that may be in such condition because of the nematode infestation. After the beetle eggs hatch the wood-boring larvae within the pine trees become infected with the nematodes if they are present. The following year when the adult beetles emerge during late spring and summer, they may act as vectors of the nematodes to previously healthy trees.

Is it the nematode or the fungus that is the primary cause of pine tree death? Is it a combination of both organisms? To address the problem, a multidisciplinary research team from the Natural History Survey and the University of Illinois has been formed. The members are J. E. Appleby, J. K. Bouseman, T. W. Curtain, E. B. Himelick, J. J. Jokela, R. B. Malek, M. M. Meyer, R. Randell, F. A. Giles, and D. J. Williams. The team will work to solve many of the unknowns about the nematode-fungus-beetle-pine relationships. It is hoped that the research efforts will find a means of preventing the loss of pines within Illinois.

Herbert H. Ross to Receive Founders Memorial Award of ESA



Herbert H. Ross, distinguished entomologist.

Dr. Herbert H. Ross has been selected posthumously to receive the Entomological Society of America's Founders Memorial Award. Dr. Ross, former Assistant Chief, Principal Scientist and Section Head (Faunistic Surveys and Insect Identification) of the Illinois Natural History Survey, and Professor of Entomology at the University of Illinois, retired in 1969.

The award will be presented at the annual meeting of the Entomological Society of America (ESA) in San Diego, California in late November 1981. The award consists of two parts: the Honoree (a former ESA member) and the Lecturer (a current member) Dr. Charles D. Michner, Watkins Professor of Entomology at the University of Kansas and member of the National Academy of Sciences, will receive the Lecturer part of the award. The Founders Memorial Award, established by the Governing Board of the Society, has been awarded annually to honor the memory of a distinguished North American entomologist. Dr. Ross is the only entomologist in the history of the ESA to be recipient of both the Lecturer (1970) and Honoree parts of the award.

A highly respected scientist, Dr. Ross published 220 scientific works, including 7 books and chapters in 6 other books. The fourth edition of his popular *Textbook of Entomology* will be published in the very near future. He was active in several scientific organizations and served as president of the Entomological Society of America (1954-55), the Society for the

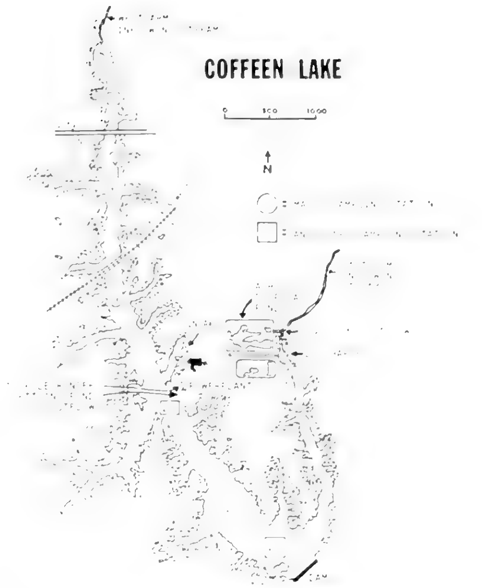
Study of Evolution (1966-67), and the Society of Systematic Zoology (1973-74). Dr. Ross influenced the direction of evolutionary biology and systematics. His evolutionary emphasis helped to evaluate systematics to its present position as a progressive, analytical and synthetic science.

In order to further honor Dr. Ross and to encourage research in systematic entomology, a memorial fund has been established jointly by the Illinois Natural History Survey and Department of Entomology at the University of Illinois. Contributions may be made to the Herbert H. Ross Memorial Fund, University of Illinois Foundation, 224 Illini Union, 1401 W. Green St., Urbana, Illinois 61801.

Trace Metals in Coffeen Lake

The Survey's trace metal laboratory is participating in a multidisciplinary three-year study of the cooling lake (Coffeen Lake, Montgomery County) associated with Central Illinois Public Service Company's Coffeen generating station. In addition to serving as a cooling reservoir for thermal effluent from the coal-fired plant, the lake has, in the past, been used for the disposal of local sewage, mine drainage, and runoff from the coal waste storage areas. Recent improvements in the disposal of coal combustion wastes at the plant have eliminated some of the sources of pollution and should contribute to an improvement in the environmental quality of the lake's ecosystem.

Samples of water, sediment, macrophytes and three species of fish (black bullheads, gizzard shad and largemouth bass) were collected from four established stations representing various thermal regimes and were analyzed for their content of 18 chemical constituents by former Survey analytical chemist Kenneth E. Smith and his associates. During the first two years of the study, the constituents in the collected samples were more concentrated in the first half of the cooling loop of the lake, the area that formerly received discharges from the slag and fly ash ponds, than elsewhere in the lake. In addition, the chemical constituents in all samples tended to decrease in concentration from the first year of study to the second year, the time period when improvements in disposal of coal combustion wastes at the plant were implemented.



Map of Coffeen Lake showing sampling stations of trace metals.

The mean concentrations of mercury in water exceeded the maximum safe tolerance level for freshwater aquatic life (0.05 ppb, as determined by the U.S. Environmental Protection Agency) in eight of the ten months during the first year of study and in six of the nine months during the second year. However, there was at least a six-fold decrease in average mercury content during the second year. Analysis of water samples collected during the third year of the study is in progress. Preliminary results indicate that the levels of mercury and many of the other chemical constituents continued to decrease during the third year.

There has been concern about the reported reproductive failure in fish inhabiting lakes contaminated with selenium. The levels of selenium in gizzard shad and largemouth bass from Coffeen Lake did not change appreciably during the three-year study (averages of 1.27 ppm and 1.72 ppm, respectively). Black bullheads contained very low selenium levels (average of 0.35 ppm). Third-year levels in carp,

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bluegills and channel catfish were 1.17, 1.19 and 0.80 ppm, respectively. These levels are well within the range of concentrations (0.5-7.0 ppm) reported for fish from other lakes where fish reproduction is normal. Thus the reproductive success of fish in Coffeen Lake should not be affected by selenium at the present.

In order to detect any increased concentration of particular chemical constituents leaving the plant, a mass balance determination of constituents entering (via coal) and exiting (via slag and fly ash) has been initiated. Core samples taken at six transects of the lake during the third year of study are being analyzed by analytical chemist Susanne G. Wood and technical assistant Teresa A. Schuller to determine the concentrations of chemical constituents in the original soil and in the various layers of sediment laid down during the 14-year lifetime of the lake.

Analyses of sediment and macrophyte samples collected during the third year of the study are in progress. Preliminary results indicate a continued decrease in concentrations of the 18 chemical constituents, thus reflecting continued improvement of the environmental quality of Coffeen Lake's aquatic ecosystem.

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Cooling Lake Study Published

Reservoirs constructed specifically for the dissipation of waste heat from industry constitute a relatively new aquatic environment that presents both problems and attractive potentials. The most apparent environmental problems are those associated with waste heat from a production process; the most obvious benefits are recreational, especially the unique opportunity for open-water fishing in a northern climate during winter. To evaluate the detriments and benefits of a cooling-lake ecosystem, one must consider the physical attributes of the man-made system before attempting to understand the more complex biological relations. Those relationships include the entire food chain of the aquatic ecosystem.

Lake Sangchris, in central Illinois, provides cooling water for the Kincaid Generating Station, a coal-fired electric generating plant that was developed by Commonwealth Edison Company of Chicago in the early 1960's.

Under contract with Commonwealth Edison Company, the Illinois Natural History Survey studied this cooling-lake ecosystem intensively from August 1973 through August 1977 to determine the effects of the thermal discharge and combustion byproducts on the local environment. Investigations included detailed studies of water quality, plankton (minute,

Boat equipped with echo-sounding and remote temperature sensing units for determining fish distributions with respect to depth and temperature in Lake Sangchris.

Researchers collecting fish with an alternating-current electro fishing unit in Lake Sangchris.

floating or weakly swimming plants and animals), aquatic macrophytes (plants), clams, benthos (bottom-dwelling organisms), fish, fish harvest, waterfowl, trace metals, and pesticides. Some studies (water quality, benthos, clams, and aquatic macrophytes) were terminated in 1976, and others were initiated to consider the distribution of larval fishes in the water-cooling-loop portion of the lake and the effect of the impingement and entrainment of fish in the water-intake system of the power plant.

The investigative work was carried out by an interdisciplinary team of specialists. Scientists from the Sections of Aquatic Biology, Faunistic Surveys and Insect Identification, and Wildlife Research participated in the study. The administration and overall coordination of the project were handled at the Illinois Natural History Survey headquarters in Champaign, while field activities were coordinated through a field station at Kincaid, a few miles from the lake. Most of the fishery biologists were based at the field station; other team members were based in Champaign, where more extensive laboratory and analytical facilities were available.

In general, the scientists found that the power plant and the heated water discharged from it created few problems for the animal and plant life of the lake and the surrounding area. On the other hand, the heated water flowing into the lake provided some benefits, such as a longer growing season for largemouth bass and for some forms of plankton.

The strength of the Lake Sangchris case history lies in the intensive sampling program simultaneously carried out over a 4-year period by a team of investigators approaching the problems of ecosystems by looking at all trophic levels. The results of this intensive study have been published in the Illinois Natural History Survey Bulletin as volume 32, article 4, *The Lake Sangchris Study: Case History of an Illinois Cooling Lake.*

Radar Sheds Light on Bird Migration

Everyone is familiar with the sight of flocks of birds migrating during the day, either tightly clustered or in a V or echelon formation. Even at night, waterfowl are often heard calling to one another as they make their way across Illinois to the next stopover. However, the vast majority of birds neither fly during the daytime nor call regularly as they migrate — most flycatchers, thrushes, warblers, and sparrows fly silently or call only occasionally, and they fly at night. Do these smaller birds fly

in flocks, or do they make their way alone? Observations with spotlights or observations of birds' silhouettes as they fly across the face of the moon reveal that there are no tight flocks of small birds at night. Often the birds seem to fly alone; sometimes they appear to cluster in aggregations too loose to be directly seen by these visual techniques.

Taking up the question at this point, Ronald Larkin of the Wildlife Research Section has investigated the spatial arrangement of small birds at night using a special radar technique that he developed to record the passage of migrants overhead. The radar, in conjunction with a minicomputer, operates as a bird-counting machine, registering the position in space, time of occurrence, and apparent size of each bird passing through the radar beam. As he reported at a recent International Symposium on Avian Navigation in Pisa, Italy, Larkin obtained good evidence that birds sometimes do, indeed, form loose clusters at night. The distance between a bird and its nearest neighbor in one of these clusters was found to be in the region of 50–100 meters. Quantitative comparisons with computer-generated patterns of "bird" positions (random distributions from a so-called Monte Carlo method) showed that chance events could not have generated the observed patterns.

The loose clusters of birds pose a peculiar problem: If they really represent flocks, how do the birds stay together? It is not likely that the remainder of the "flock" is easily seen by a bird flying several hundred meters above the ground at night, and few species vocalize enough at night to allow auditory communication among flock members. To shed light on this problem, Larkin hypothesized that small birds do not commonly fly in flocks at night, but rather that some agent in the atmosphere causes the birds to aggregate without actual communication. The distinction is often important in field observations: birds congregated around a bird feeder are attracted to a feature of their environment, and the birds may or may not be a social unit.

Atmospheric motion was hypothesized to be the agent causing the birds to form clusters as they fly, not the general wind patterns aloft but the smaller details of the air motion. These small-scale motions (having dimensions of a few hundred meters to a kilometer or two) have been intensively studied by atmospheric scientists in the last 10 years or so; they are important in smog dispersal, in turbulence which imperils aircraft, and in generating the forces which drive storms and other large-scale disturbances.

Examination of the paths taken by weather balloons released at the radar site, just before or just after the clumping of birds was documented, revealed that when the birds were clumped, wind speeds or directions were different at different altitudes. This phenomenon is called wind shear. In one case, no wind shear was found and birds were not clumped. Wind shear almost always generates small-scale waves of the same general kind as those which a breeze generates as it blows across the surface of calm water. Therefore, at least until more definitive data are taken, we can imagine that birds flying at night are acted upon by subtle motions in the atmosphere, resulting in the clumping of birds in loose aggregations. Birds might preferentially fly in certain regions of air to save energy or to obtain navigational information. Or atmospheric motion may simply bunch the birds like flotsam on the sea.

Air-Borne Pollutant Affects Soybeans

Sulfur dioxide (SO_2) is a gaseous discharge from industrial and power plants, and at times, its concentration in the air can be high enough to produce poisonous effects on plants. At a high enough concentration, SO_2 causes a water-soaking appearance as well as interveinal chlorosis in plant leaves. At the cellular level, SO_2 affects a number of events, including transpiration, respiration, and photosynthesis. The exact sequence of events is unclear, but SO_2 does interfere with the structure and permeability of cellular membranes, and it has been suggested that SO_2 affects the lipid component of membranes. However, studies to demonstrate the SO_2 effect on lipid metabolism are few.

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Research scientists in the Section of Botany and Plant Pathology, in cooperation with the Argonne National Laboratory, have undertaken studies to determine what effects, if any, SO_2 might have on the various leaf lipids of soybean plants exposed in open-air fumigation systems. In an open-air fumigation system, which consists of an array of pipes suspended over the crop, the pollutant is released through small openings at controlled rates, and thus the plants are exposed under environmentally realistic conditions. With this system, of course, no comparison is made against plants grown under "clean air."

Sixty-day-old soybean plants exposed to 79 parts per hundred million of SO_2 for 20 days for an average daily period of 5 hours showed a marked change in fatty acids, both as to quantity and composition. The free fatty acids and polar lipids were greatly reduced with SO_2 treatment, while the fatty acid esters increased. A simple overall SO_2-induced shift in lipid metabolism is very unlikely, since the quantitative increase in fatty acid esters was almost entirely due to an increase in linoleic acid, a highly unsaturated fatty acid, while the decrease in free fatty acids was more general. The degree of unsaturated fatty acids influences membrane viscosity and, hence, membrane-related processes.

Survey studies have clearly shown an increase in the unsaturated fatty acids with SO_2 open-air fumigation, and this change in lipids probably contributes to the increase in all permeability and to the water-soaking appearance of leaves. Thus, we have gained another building block of knowledge about how an air-borne pollutant affects one of our major agricultural crops.

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Spawning Habits of Darters

Darters (Family Percidae) are a diverse group of about 148 species of fishes that are found only in North America. They are second to minnows (Cyprinidae) in numbers of North American species and are extremely important components of our aquatic ecosystems. Twenty-six species occur or formerly occurred in Illinois.

For short-lived species such as darters, which have a maximum life-span of 1½ to 4½ years, the annual breeding season is a critical period. One or two unsuccessful breeding seasons can eliminate a population. Ecological conditions necessary for successful reproduction vary from species to species. Information on when, where, and under what environmental constraints darters lay their eggs is requisite for their protection and conservation.

Such information is available in the scientific literature on 50 species of darters. During the spring of 1981, Survey ichthyologists L. M. Page and M. E. Retzer obtained data on four more species, the mud, bluntnose, coppercheek, and smallscale darters.

Darters spawn in three general ways: they bury their eggs in the substrate and abandon them, attach them over a relatively large area to objects (usually plants or rocks) above the substrate and abandom them, or cluster them on the underside of an object (rock or log) and guard them until they hatch. Burying eggs is characteristic of primitive species, including all six species of the genus *Percina* for which data are available, and of some species of the genus *Etheostoma*. Attaching and clustering eggs, derived behaviors, are known only in *Etheostoma* but have arisen independently in several subgenera.

The subgenus *Nothonotus* is the only group of darters in which some species bury their eggs and others cluster them. In 1939 in Pennsylvania, eggs of the spotted darters, a species of *Nothonotus*, were found clustered on the undersides of stones held as territories by males. From 1939 to 1981, no other species of *Nothonotus* was

Male, smallscale darter and cluster of eggs on overturned rock (Photo by Les Woodrum, Survey photographer).

reported to cluster its eggs. In May 1981 the Survey ichthyologists found four clusters of eggs of the coppercheek darter in a large rubble riffle in the Buffalo River in Tennessee. Eggs were difficult to find in the swift water, and it was especially difficult to capture a male guarding a cluster of eggs. However, one male was captured beneath a stone with a cluster of eggs attached. To confirm the egg-clustering habit of the coppercheek darter, two males and four females were returned to the Survey and placed in an aquarium outfitted with a current pump and two stones as potential clustering sites. Within three days, one male had established a territory under a stone and was guarding three small clusters of eggs.

Also in May 1981, in a fast riffle in Stones River, Tennessee, a cluster of eggs and an attendant male smallscale darter, another member of the subgenus *Nothonotus,* were found. The cluster contained about 346 eggs and was essentially identical to those of the spotted and coppercheek darters. The smallscale darter is a rare species, existing only in a few widely separated rivers. Protection of the species will require maintenance of these rivers as free-flowing, clean streams with suitable sites for clustering eggs.

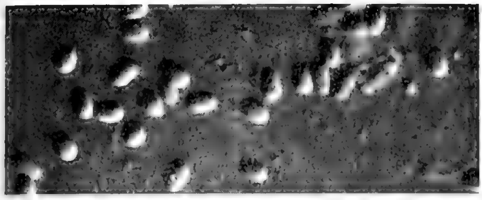
The other two darters studied in 1981 were the mud and bluntnose darters, both common in Illinois. Individuals of each species were transferred at the peak of their spawning periods to aquaria at the Survey and given a variety of substrates on which to lay their eggs. Following elaborate courtship behavior, both species attached their eggs to plant material. Although the habitats (sluggish stream pools) of both species suggested plant material as the probable site for egg deposition, two close relatives of the mud darter, the rainbow and orangethroat darters, bury their eggs in gravel riffles.

Hangingfly Parasites

Mecoptera are medium-sized insects, the adults of which range from ½ to 1 inch in length. The two most common families of Mecoptera (Panorpidae and Bittacidae) occur throughout Illinois and generally are found in moist shady woodlands, especially along streams. Adults of the Panorpidae (scorpionflies), represented in Illinois by nine species, generally feed on dead or dying insects. Adults of the Bittacidae (hangingflies) are predaceous and hang by their forelegs from the foliage of low shrubs and herbs where they capture a variety of small prey, including mosquitoes, flies, aphids, and caterpillars. Six species of hangingflies occur in Illinois.

Little is known about the biology of most species of Mecoptera, especially their

Adult hanging fly *Hyalobittacus apicalis* (Photo by former Survey photographer, W. D. Zehr).



Spores of a microsporidium from *Hyalobittacus apicalis.* Wet mount photographed with Nomirski interference contrast (800X) (Photo by J. V. Maddox, Survey entomologist).

natural enemies. Some of these natural enemies are being investigated by Survey entomologists J. V. Maddox and D. W. Webb. They found that entomopathogenic fungi of the order Entomophthorales occasionally infect adult Mecoptera but infection rates were less than 5 percent. Neogregarine (Phylum Protozoa) infections were also found in adult Mecoptera but again affected less than 5 percent of the total mecopteran population.

By far the most common pathogens fund in Mecoptera were obligate parasites of the Phylum Microspora (recently moved from the Phylum Protozoa). Adults of the hangingfly, *Hyalobittacus apicalis,* frequently were infected with a yet undescribed microsporidium. Infections were widespread throughout the range of *H. apicalis* in Illinois and have been observed every year since 1971. In one study area, from which *H. apicalis* adults were collected weekly, the infection rate steadily increased from 5 percent in mid-May, when *H. apicalis* adults first start emerging, to 90 percent in late July, just before *H. apicalis* populations disappeared. Fat body and midgut tissues of *H. apicalis* adults were infected by this microsporidium and heavily infected adults soon died from the infection.

Microsporidia are normally transmitted from host to host by a resistant spore and in addition they may be transmitted through the egg from an infected female to her progeny. At this time, we do not know how the infection increases in *H. apicalis* throughout the season or whether the disease is transmitted through the egg to larval offspring.

The microsporidium from *H. apicalis* as well as other microsporidia have been found infecting other species of Mecoptera. Some of these microsporidia are being described as new species while studies on their role as mortality factors in mecopteran populations are continuing.

James Cedric Carter, 1905-1981

J. C. Carter, Plant Pathologist and Emeritus Head of the Section of Botany and Plant Pathology at Illinois Natural History Survey and Emeritus Professor of Plant Pathology at the University of Illinois, died September 27, 1981, at the age of 75 years.

He served as an assistant in plant pathology at Purdue University from 1931 to 1934 and as a technical research assistant on fungicide studies at the University of Delaware during the summers of 1931 and 1932. On May 14, 1934, he joined the Section of Applied Botany and Plant Pathology of the Illinois Natural History Survey as an Assistant Botanist. He was appointed Head of the Section of Applied Botany and Plant Pathology on January 1, 1955 and received a joint appointment to the faculty of the University of Illinois as Professor of Plant Pathology that same year.

After 40 years of outstanding service and devotion as a researcher, educator and administrator, he retired on June 1, 1974 and moved to Crawfordsville, Indiana, near the place where he was born. He continued part-time teaching at Wabash College in Crawfordsville during his retirement years.

James Cedric Carter.

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Dr. Carter was an authority on shade and ornamental tree diseases. He worked on numerous diseases of trees and shrubs and was a primary influence in the early development of modern urban arboriculture in the United States. Some of the major tree diseases on which he worked were Verticillium wilt, wetwood of elm, anthracnose of oak and sycamore, elm phloem necrosis, Dutch elm disease, and several canker diseases of trees and shrubs. For over 25 years he was considered the foremost authority in the Midwest in the diagnosis of infectious and noninfectious diseases of trees and shrubs. His extensive knowledge and experience in observing symptoms of diseases, sectioning of fungal fruiting bodies, and identification of cultured organisms from infected plant material made him a highly valued resource person.

He was the author or co-author of over 140 scientific publications. His book *Diseases of Midwest Trees* (first published in an earlier form in 1964 as *Illinois Trees: Their Diseases*), remains an important reference on diagnosing tree diseases. In 1970 he published a companion manual on the selection, planting, and care of trees that is widely used by professional horticulturists and arboriculturists.

Dr. Carter received many awards and honors during his career. Among them were a special award from the National Arborist Association for his research on the wetwood disease of elm; the Outstanding Service and Past Presidents awards from the Midwestern Chapter, International Society of Arboriculture; and the Author's Citation, Past Presidents, and Honorary Life Member awards from the International Society of Arboriculture. He was an honorary member of the Indiana Arborist Association and the Illinois Commercial Arborist Association. For several years he served as chairman of the Illinois Tree Experts Examining Board.

Dr. Carter contributed significantly to the professional field of arboriculture through his personal research and his many years of association with the International Society of Aboriculture. He was a gracious person who freely shared his knowledge, experiences, and inspired his professional associates. His friendly and kindly disposition were his constant personal traits. Dr. Carter is still with us in the form of the personal inspiration he gave to those who worked with him and the many professional contributions he made for the improvement of the urban environment through the protection and maintenance of shade trees.

Dr. Carter married Margaret Lucile (Rogers) Carter, also originally from Indiana, on August 18, 1934. They always graciously loved and cared for each other throughout their 47 years of marriage. He is survived by his wife, one son, two daughters, 10 grandchildren, and three great-grandchildren.

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Pheasants Threaten Jasper County Prairie Chickens

The introduced ring-necked pheasant has replaced the native prairie chicken over much of the great plains and eastern tall grass prairie region during the last half century or so. Most of the shift in numbers and distribution of the two species resulted from the conversion of native prairies, and later of such substitute prairies as hayfields, pastures, and grass-seed meadows, to the production of corn, soybeans, and small grains. Pheasants are more tolerant of intensive agriculture than are prairie chickens. According to many wildlife professionals and laymen, the loss of the native bird and the gain of the exotic was purely a matter of habitat change. This contention is not entirely true according to recent evidence gathered by Survey wildlife biologists Ronald L. Westemeier and John E. Buhnerkempe.

Once numbering in the millions, prairie chickens in Illinois had been reduced to approximately 300 birds in the spring of 1981. Near Bogota in Jasper County, prairie chickens responded dramatically from 1968 to 1972 to the development of 1,000 acres of nest sanctuaries by increasing their numbers from about 80 to 400 birds. Similarly, 640 acres of sanctuaries were established near Kinmundy in Marion County through the combined efforts of the Natural History Survey; the Illinois Department of Conservation; the Prairie Chicken Foundation of Illinois (now disbanded); and the Illinois Chapter, The Nature Conservancy, plus other agencies and private conservationists. Curiously, the Kinmundy flock now exceeds the Bogota flock despite the large difference in sanctuary acreage. A critical factor differentiating trends in abundance of prairie chickens on the two areas appears to be the development of a thriving pheasant population over the past 10 years at Bogota, whereas the Kinmundy area has almost no pheasants.

The adverse impact of pheasants on prairie chickens at Bogota may be summarized as follows: (1) Both the population of, and nesting effort by, prairie chickens have become increasingly concentrated on the two central sanctuary units, with the five peripheral sanctuary units largely abandoned or little used. (2) Harassment of courting and mating prairie chickens by pheasants has become relatively common. (3) The nesting effort of prairie chickens (number of nests, but espe-

A female prairie chicken entering her nest.

cially hatches per hen) has been substandard in several springs (i.e., increasing numbers of hens have apparently not nested) since pheasants have become abundant at Bogota. (4) For the prairie chickens that do nest, there is an increasing likelihood of parasitism by pheasants, resulting in desertion, predation, or if hatching occurs, a parasitic pheasant brood and the probable loss of the prairie chicken brood. Twenty-five prairie chicken nests were found that contained eggs from both species; success in hatching was significantly lower for these nests than for prairie chicken nests that contained only prairie chicken eggs. In two cases the pheasant eggs were hatched, but the prairie chicken eggs contained dead but nearly full-term embryos. The incubation period for pheasant eggs is about 2 days shorter than the incubation period for prairie chicken eggs. (5) If parasitism does not occur, the probability of nest abandonment is increased, apparently related to the presence of pheasants. (6) If parasitism and desertion do not occur, increased embryonic mortality currently results in 1-2 fewer than normal prairie chicken chicks hatched per clutch. This fact suggests altered behavior of nesting hens, such as reduced attentiveness during incubation due to harassment of pheasants.

No species can long withstand such adversities as those imposed by pheasants on prairie chickens, when added to more normal problems of predation, weather, and intensive land use. At this point, the survival of prairie chickens in Jasper County must be regarded as uncertain, perhaps doubtful, with pheasants at their present high levels. Should the pheasant become well established on the Marion County prairie chicken sanctuaries — a distinct possibility — the extinction of the prairie chicken in Illinois seems probable. A sustained program of pheasant control is clearly called for, and is being considered, in programs to preserve the Illinois prairie boomer.

Drought and Spruce Canker

Blue and Norway spruces are highly prized as landscape trees throughout Illinois. Very blue selections of Colorado spruce, called "shiners," and the grafted blue cultivar Koster are some of the most expensive landscape plants available. The retail price of a young blue spruce at the nursery may reach $20 per foot of height. Therefore, disease or insect damage on a blue spruce can be of great concern to the grower and even more so to the homeowner.

Fortunately, spruces grow well in the Midwest, with few insect or disease problems. However, a stem canker disease caused by the fungus *Valsa kunzei* appears to be causing increasing damage on both blue and Norway spruces. Although the disease has been recognized for many years, attempts to cause infection by artificially inoculating vigorous spruce seedlings were unsuccessful. There seemed to be some association between environmental stress and the severity of infection, but research to confirm this association was lacking until recently.

Survey plant pathologist D. F. Schoeneweiss has conducted research on the role of environmental stresses in diseases of woody plants for over a decade. When he inoculated stems of Colorado blue spruce with the canker fungus and subjected the plants to controlled drought stress, typical stem cankers formed, while nonstressed stems remained resistant. The cankers appeared as enlarging areas of dead bark surrounding the inoculation points. Although the fungus was able to survive and grow to some extent in the wood of both stressed and nonstressed stems, injury was confined to the bark tissues of stressed stems. In contrast, most canker fungi attack and kill cells of the water-conducting tissues in the wood, causing wilting and dieback of branches.

The level of water or drought stress imposed on spruces in this study was quite severe, yet stressed plants did not exhibit visible signs of wilting. Needles and twigs of spruce are quite rigid, and it is usually not possible to tell whether a spruce is under water stress by its appearance. Since drought stress may cause spruces to become susceptible to attack by *V. kunzei*, proper maintenance of landscape spruce trees

A Colorado blue spruce from which the lower branches had been removed over a period of several years because of *Valsa* canker infection. Right: A swollen stem canker with the exuding pitch characteristic of the disease.

should include a regular watering schedule, particularly during drought periods.

In his research program on stress and plant disease, Schoeneweiss has shown that other environmental stresses, in particular hard freezes following mild weather in the fall, may cause woody plants to become susceptible to attack by stem canker fungi. Studies are now in progress to determine the possible role of freezing stress in the appearance of *Valsa* canker on spruce.

Experimental Ecological Reserves

The need for preserving natural areas has long been recognized at both national and international levels. Biosphere Reserves are being established at the international level to conserve genetic diversity and encourage environmental research and education. In the United States national wilderness areas and state nature preserves serve as ecological reference points for

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base-line monitoring. Research in such preserves is necessarily observational so that the area can remain as unaltered by man as possible.

The need for other areas where experiments can be performed has been recognized only recently. In 1974 the Federal Committee on Ecological Research recommended Experimental Ecological Reserves "to provide sites for manipulative experiments, management testing, and observations of the results of human impact." The Institute of Ecology, a consortium of private, state, and national institutions dedicated to interinstitutional research and policy analysis in ecology, evaluated potential Experimental Ecological Reserves in the United States, Virgin Islands, and Puerto Rico. In 1975-1976, 67 terrestrial sites were selected, and in 1980-1981, 29 aquatic sites, including one submitted jointly by the Natural History Survey and Western Illinois University. The site is unusual because it consists of three locations on two rivers: the Alice Kibbe Life Science Station of Western Illinois University on Pools 19 and 20 of the Mississippi River, the Survey's River Research Laboratory at Havana located at the midpoint of the Illinois River, and the Survey's other river laboratory at Grafton at the confluence of the Mississippi and Illinois rivers.

These laboratories will provide access to two large alluvial rivers subject to quite different degrees of human impact. The Illinois River has most certainly been the subject of large-scale manipulative experiments although the experiments were not designed by biologists. Observations of the results of human impact, such as the diversion of Chicago sewage into the river starting in 1900, have been made for over 100 years. The Mississippi River has been influenced relatively less by man.

The joint Natural History Survey-Western Illinois University site is the only Experimental Ecological Reserve selected in Illinois and one of only six sites (including terrestrial sites) in the North Central Plains, which includes substantial parts of 12 states. Together with the other 95 sites, the Big River Site should help to achieve the national goal of providing a network of research facilities where the functioning of major ecosystems of the United States can be investigated.

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Project Gypsy Moth

A bright, sunny June afternoon with millions of caterpillars crawling over patio furniture, sides of homes, and crawling down completely defoliated trees could be a typical scene in an Illinois woodland in the not too distant future. The gypsy moth invasion into Illinois has begun. In 1981 personnel of the Illinois Department of Agriculture captured 2,634 male gypsy moths in traps located throughout the state. The largest number of moths caught were in the Chicago region. The steadily increasing number of captures during the past few years indicates that outbreaks of gypsy moth caterpillars are imminent.

Gypsy moth caterpillar (full grown length ca. 50 mm). (Photo by J. E. Appleby).

The gypsy moth overwinters in the egg stage. Masses of eggs containing from 75 to 800 eggs are often found along protected areas of the tree trunks, on wooden fence posts, in rocky crevices near the infested trees, on camping trailers and tents, and in a multitude of other places. Eggs hatch in the spring when the tree leaves are unfolding. The newly hatched caterpillars climb to the treetops and often spin down on silken threads before feeding begins. Wind currents during this period can transport the caterpillars for miles. If windblown caterpillars fall on a suitable host, feeding begins. Gypsy moth larvae feed on many kinds of trees and shrubs but the favorite hosts are oaks. Oak trees which are defoliated for 3 consecutive years often die. The caterpillars feed voraciously on the plant foliage for about 5 weeks. When mature the dark colored caterpillars can be recognized by the 5 pairs of blue and 6 pairs of rust colored dots down the back. With the completion of feeding the larvae wander over tree trunks, the ground, and surrounding structures where they spin cocoons and change into the inactive pupal stage which lasts about 3 weeks. Pupae can be transported great distances if they are attached to automobiles, campers, and railroad cars. It is during years when high populations occur in the eastern states that pupae are often transported into the Midwest. Upon emergence from the pupa, the nearly flightless white female moth produces a powerful odor or pheromone which attracts the male moths. (It is the synthesized pheromone which is used in traps to capture the male moths.) The dark brown male moths mate with the female, and shortly thereafter the female moths deposit the egg clusters. The egg clusters also can be transported great distances by vehicles.

High populations of the gypsy moth generally exist for about 3 years, after which there is a dramatic decline in population due to diseases, parasites, and predators.

Presently, scientists at the Natural History Survey are planning strategies to cope with the anticipated gypsy moth problem. Educational materials to inform the public on how to deal with this problem are being planned. The introduction of parasites, predators and gypsy moth diseases will be studied, and the public will be encouraged to aid in combating the pest.

Carolina wren, Urbana, Illinois, 15 May 1971. (Photo by J. W. Graber).

Disaster Species and Blizzards

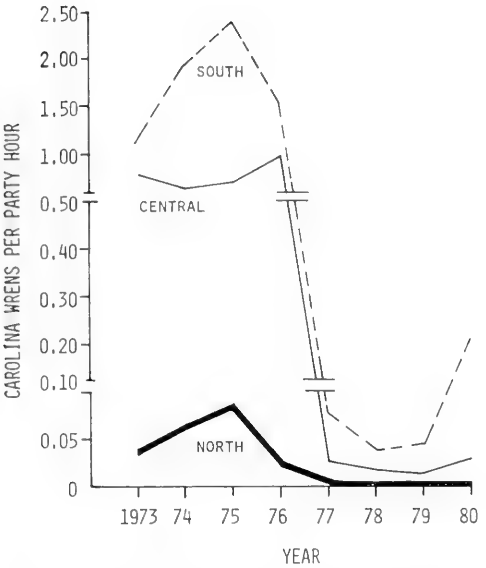
Certain populations of birds are especially susceptible to winter's cold and exhibit sizeable declines in years with prolonged periods of freezing temperatures. The problem probably is accentuated by snow cover and shortages of mast and other natural foods. Species that are notably subject to such winter mortality have been dubbed "disaster species," and in the eastern United States include the Carolina wren, hermit thrush, and eastern bluebird, all of which winter in Illinois. Winter kills of these species are probably particularly severe in the latitudes between 35°-39°N — far enough south to have large populations of the sensitive species and far enough north to have the kind of weather which produces kills. But even farther south, populations of more sensitive species such as the house wren and eastern phoebe succumb when the winters are unusually cold.

January 1982 was the 5th anniversary of the worst such kill on record in Illinois and surrounding states. The blizzard of January 1977 virtually killed Illinois' entire populations of the winter wren, Carolina wren, hermit thrush, golden-crowned kinglet, ruby-crowned kinglet, and field sparrow. Other species (brown thrasher, eastern bluebird, and most of the ground-foraging sparrows) suffered population losses of 80-90% before the weather ameliorated in February. The occurrence of this high mortality so quickly over such a large area was unprecedented in the experience of survey ornithologists Jean and Dick Graber who described the kill in a 1979 paper.

Certain general patterns, relating to survival, emerged from the study. There were massive shifts of populations between habitats, as birds searched for food resources. Because of human help in providing food, birds survived better in urban areas than in their natural habitats. Not surprisingly, small species fared worse than large species, and the higher populations were above their average winter level, the more seriously they declined.

The 1977 kill was the worst on record, but the sensitive species have endured massive kills before — in (notably) 1941 and 1958-1959. Despite their susceptibility, these populations are healthy as indicated by their ability to recover from such blows. Bluebirds, which were decimated in 1958, were starting to recover by 1962 and were nearly back to normal by 1964. Because of the severity of the 1977 kill and its extent from Iowa and northern Arkansas east to Pennsylvania and West Virginia, there was concern about the chances of recovery.

Precisely how the recovery takes place is not understood. Would there be a vast area devoid of, say, Carolina wrens for many years to come as birds filled in slowly from the edges of the areas where they survived? Though we still don't know the recovery process, the Christmas bird counts provide a measure of how fast it is occurring. The counts made mainly in December of each



Numbers of Carolina wrens seen on Christmas counts in southern, central and northern Illinois before and after the blizzard of January 1977.

year did not show the kill of Carolina wrens until about a year later. By that time there was already a tiny population in southern Illinois, but none in the central or northern parts of the state. In spite of two more bad winters, the wren population held on, and by December 1980 (the last Christmas counts available) was starting to climb. Carolina wrens winter especially in the bottomland forests of southern Illinois. Censuses by the Grabers in that habitat in late December 1981 revealed population densities of Carolina wrens back to the level they were before the blizzard of '77. We have to admire the resiliency of these little birds.

Genetic Studies of Largemouth Bass

The largemouth bass, *Micropterus salmoides,* is one of the most sought after and highly managed sport fish in the United States. Its original range has been considerably expanded through extensive stocking programs. Almost any body of water that could conceivably support a population has been stocked, and in many cases stocked repeatedly with largemouth bass. Unfortunately, little consideration has been given to the genetic consequences of many of these programs. Largemouth bass fingerlings are sometimes transported great distances and stocked into waters with environments quite different from those native to the fingerlings. Often these fingerlings are stocked into lakes already containing largemouth bass populations. The possibility exists that such stocking practices may irreversibly alter the genetic structure of these native laregmouth bass populations. It is imperative to determine the magnitude of such changes.

Scientists in the Aquatic Biology Section of the Illinois Natural History Survey and the Departments of Animal Science and Genetics and Development at the University of Illinois are currently investigating this problem. David P. Philipp, William F. Childers and Gregory S. Whitt have completed a survey funded by the Electric Power Research Institute to determine the genetic variability existing within and among largemouth bass populations throughout the United States. Specifically, the biochemical genetic composition of each of 90 populations of largemouth bass, *Micropterus salmoides,* was analyzed using vertical starch gel electrophoresis followed by histochemical staining of the gels to detect gene products. The phenotypes at each of 28 enzyme loci were determined for 20 individuals per population to assess the relative number of gene differences among largemouth bass populations.

The results of these analyses revealed that significant differences exist among largemouth bass populations from different areas of the country. Most dramatically, the two recognized subspecies of largemouth bass, the northern subspecies, *M. s. salmoides,* and the Florida subspecies, *M. s. floridanus,* are genetically distinct. Each subspecies has unique gene products for certain of its genes. A given population of laregmouth bass, therefore, can be analyzed electrophoretically to determine the percentage of genes contributed by each subspecies. The results indicated that the ranges of the two subspecies, as well as that of the intergrade zone, are different from those proposed originally. Since certain gene products are correlated with environmental parameters, it is highly probable that the genetic composition of individual

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laregmouth bass is integrally involved in determining the thermal tolerance/preference limits of this species. This has tremendous ramifications for fisheries management practices.

Past hatchery procedures have all too often overlooked genetic differences between populations. It is particularly distressing to observe the degree to which "Florida largemouths" are being propagated and widely dispersed in states other than Florida. The viability and reproductive success of these introduced bass in these foreign environments is unknown.

The present demonstration of genetically divergent populations suggests that many states may be wasting valuable resources by attempting to introduce "Florida bass" of questionable genetic composition into their lakes. Once genetic differences between largemouth bass populations are better understood, and once the role that short-term and long-term fitness plays in determining the range and distribution of phenotypes is more fully elucidated, fisheries biologists will be in a better position to design effective management programs.

This study has generated the following recommendations for improving management procedures for largemouth bass:

1. Each state should be responsible for analyzing samples of largemouth bass from a number of lakes and rivers throughout its area to determine the genetic composition of these populations so that baseline data will exist from which sound management plans can be constructed.
2. Each state should determine the genetic composition of samples of all largemouth bass produced in its hatchery system, as well as of samples of all largemouth bass obtained from other sources, to insure genetic compatibility with native stocks.
3. Each state should select hatchery brood stock regularly from wild populations highly representative of the area which that hatchery serves. Several batches may be required to produce several different stocks of largemouth bass, each to be used for different environments or situations.
4. The effectiveness of the stocking program should be evaluated and long-term effects on the genetic composition of specified laregmouth bass populations should be monitored.
5. All precautions should be taken to insure that the genetic integrity of the two subspecies of largemouth bass are protected from uncontrolled promiscuous stocking programs.

The Illinois Department of Conservation in conjunction with the Illinois Natural History Survey is currently practicing these recommended procedures in the design and implementation of the largemouth bass management programs within the State of Illinois, procedures which should result in more efficient and effective management of this important game fish.

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What Are Lichens?

Lichens are mysterious and unusual plants, according to Survey mycologist and lichenologist J. Leland Crane. Part of the mystery lies in their very nature. An individual lichen is a unique organism composed of a microscopic green or blue-green alga and a colorless fungus. The alga and fungus live together in a mutually beneficial association termed "symbiosis." The plant body that is formed has no resemblance to either the algal or the fungal component.

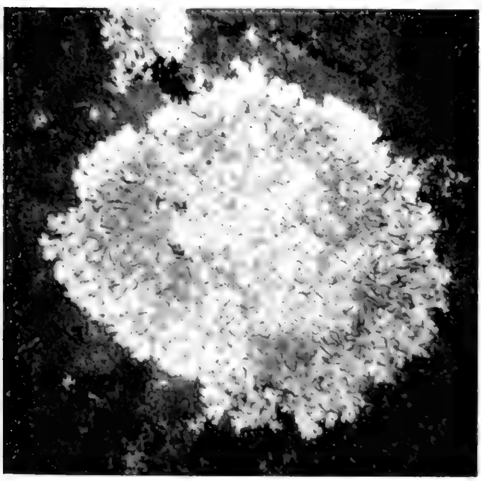
The algal partner provides food energy through photosynthesis, and the fungal partner lives on this food, makes up the bulk of the lichen body, protects the alga from dessication, absorbs mineral elements and water, and synthesizes many essential organic compounds.

Lichens are widely distributed and are found on a great variety of substrates, such as rocks, trees, woods, and soil. They are found in the Arctic (where they are dominant in the tundra) and the Antarctic, from sea level to alpine habitats, in deserts, and in freshwater and marine environments. Some lichen communities last for centuries in the Arctic and Antarctic, but if the environment is disturbed, they are eventually replaced by mosses, liverworts, and higher plants.

Lichenology, the study of lichens, still lags behind studies of the higher plants and even of mosses and fungi as a developing science, but this lag means that it is an exciting field where many new discoveries can be made.

Movements of White-tailed Deer

Movements of wild animals have long interested biologists, and a large number



Two species of the lichen genus *Parmelia* attached to rock (left) and to tree branches (right). (Photos by J. Leland Crane)

of studies have included descriptions of animal movements. Many birds are well known for their long-distance flying ability and seasonal migrations of thousands of miles. The movements of mammals are generally less familiar but can be equally remarkable. The caribou, for example, may travel 500–600 miles between its winter and summer ranges.

Research has been done throughout North America on the movements of white-tailed deer. Though not as mobile as the caribou, deer travel greater distances than most people realize. In the more southern states, where seasonal changes in weather are slight, deer move only short distances, usually less than 3 miles. In the north, where weather changes are more extreme, deer migrate between summer areas and winter "yards" or concentration areas, which may be as much as 25 miles apart.

Deer movements in Illinois have been examined in the past by biologists of the Natural History Survey and Southern Illinois University in the more forested southern part of the state. They found that marked deer traveled up to 22 miles from the release site, with yearling bucks going the farthest.

Until recently, very little was known about the movements of deer in the northern, more agricultural areas of the state. Survey biologists C. M. Nixon, Lonnie P. Hansen, and James E. Chelsvig are currently studying the movements of deer at Robert Allerton Park near Monticello in Piatt County. The deer are captured and fitted with radio-transmitter collars or some form of visual identification, such as ear streamers or plastic reflector collars.

About 57 percent of the deer marked during the first 2 years of the study are believed to have left the park. Some deer migrate between their winter range in Allerton Park and their summer range somewhere within 15 miles of the park. Other deer that have left the park but have not returned have been observed at Champaign (27 miles), Lake Shelbyville (33 miles), Chesterville (24 miles), Homer (38 miles), Taylorville (48 miles), Sigel (55 miles), and Morris (91 miles). These results indicate that deer in Illinois

A doe fawn about 8 months old wearing a reflector collar. (Photographed at Robert Allerton Park by James E. Chelsvig)

are not as sedentary as is generally believed. Some questions that remain unanswered are how many deer move into Allerton Park from other areas, and how far do they come? Answers to these questions will have to come from future trapping and tagging efforts in other areas of the state.

Dynamics of Insect Adaptation to Soybeans

Economic entomologist Marcos Kogan recently prepared a report showing how insect pests adapt to soybeans, what kinds of soybean pests may occur in the future, and the long-term concerns of integrated pest management programs for soybeans.

The species composition and structure of arthropods (a phylum that includes crustaceans, insects, and spiders) associated with a crop are the result of a highly dynamic adaptive process. The main components of this process are the crop with its complement of production practices, the associated fauna inhabiting or crossing the crop space, and the physical environ-

ment in which the crop and the fauna coexist. When a crop plant is introduced into a new region or when the area under cultivation to a crop is expanded, there is a rapid accumulation of arthropod species capable of using the new food resources as they become available. The crop is colonized by numerous arthropod species that may or may not remain associated with it. Certain of these species may, in time, become predominant elements of the fauna and eventually reach pest status.

The development of arthropod communities on soybeans in the western hemisphere has followed such a process of adaptation. The soybean, a plant native to eastern Asia, was introduced into North America in the early 1800's. In 80 percent of the world soybean acreage this crop has been extensively grown for less than 50 years.

As one tries to assess the variation in pest status of arthropod species within regional soybean arthropod communities, four key questions must be addressed. (1) Are all major plant parts, at every growth stage, efficiently exploited by arthropod pests? (2) After the introduction of soybeans into a new region, what have been the major sources of colonizers? (3) What are the sources of potential new colonizers after an initial species equilibrium has been achieved? (4) Can control practices in an integrated pest management program accelerate or delay the adaptive processes that lead to a fuller exploitation of soybean resources by arthropods?

Kogan attempted to answer these questions by comparing soybean arthropod communities in North and South America, regions where the crop has been introduced rather recently, with arthropod communities in east Asia, the probable center of soybean origin.

The answer to the first question (niche occupancy) is that in the Orient there is a rich fauna on soybeans capable of effectively exploiting most identifiable resources. The most serious pests in this region are oligophagous (eating only a few, usually related, plants) and are well adapted to soybeans. In America, however, most major soybean pest species are polyphagous (eating various plants). Furthermore, it seems that several critical niches are unoccupied or incompletely occupied. This is particularly true for pod-boring species in the United States and to some extent also in major growing areas in Brazil.

The second question concerns the sources of colonizers of soybean fields after the plant has been introduced into new areas. When soybeans have been introduced into new regions in North and South America, they usually have replaced other crops or the natural plant cover (meadows or woods). Certain elements of the existing fauna in the region have adjusted to the new crop. These adjustments have been more or less gradual, and in general have included: (1) the expansion of host ranges by polyphagous species to include the soybean in their diets, (2) the gradual adjustment to feeding on the soybean by oligophagous species normally associated with cultivated or wild legumes, and (3) the changing of feeding habits by oligophagous species adapted to feeding on other plants so that they have become capable of eating and developing on soybeans.

The answer to the second question is, therefore, that the soybean arthropod community in North and South America is constituted of elements of the fauna that existed in the area before the introduction of the crop. The occupation of soybean niches occurred rather rapidly, generally resulting in a rich fauna associated with the crop. This fauna, however, is not specialized to soybean feeding, and in most instances, plants preferred for feeding and oviposition are other cultivated legumes or plants of the wild flora. In the Orient, however, certain species are highly adapted to soybean feeding.

The third question refers to the probability of the replacement of existing species by others that may have a competitive advantage for occupation of the same niches. These potential colonizers may result from changes in species of the native fauna or from the immigration of exotic species. Natural mechanisms capable of producing changes in the local fauna are (1) legume-associated oligophagous feed-

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ers becoming better able to exploit soybean resources, (2) greater specialization of polyphagous species with regard to the soybean, (3) shifts in the food range of non-legume-associated oligophagous species, and (4) accidental invasion of the area by exotic species.

Research shows that such shifts in feeding habits have indeed occurred in the past. The fourth and eventually most dangerous source of new colonizers is immigrant species, particularly from countries in which soybeans have been cultivated for a long time. The midwestern states may be particularly vulnerable to this kind of invasion, because species highly adapted to soybeans in the Orient occur in areas of similar latitude and overall ecological conditions. The pod borers are the most serious candidates for movement from the Orient to the Americas, and certain defoliators may represent a potential threat in the opposite direction. Early detection of possible transcontinental shifts is perhaps the only measure to forestall the impact of immigrant species.

The final question, then, is whether certain control practices can accelerate or delay the evolutionary processes that lead to a fuller exploitation of available niches in soybeans. Integrated pest management includes, among other tactics, cultural practices (such as the elimination of preferred plant hosts, the associated crops within the agroecosystem, the presence of alternate hosts as sources of colonizers, row spacing, various tillage practices, the selection of planting dates, and crop rotation), host plant resistance to pests, and chemical controls. Integrated pest management, as a multifaceted approach to the regulation of pest populations, must consider in each case the long-range effects of every control tactic. Since the ecological balance in agricultural communities is extremely delicate, any changes in these practices may bring about serious shifts in the faunal composition. Some of these have been detected in the past, and others may be predicted for the future.

The threat of an evolving, better adapted insect fauna less vulnerable to currently available control tactics must be considered in planning long-term insect pest management systems for soybeans. Monitoring these faunal shifts should be an integral part of research programs in soybean entomology.

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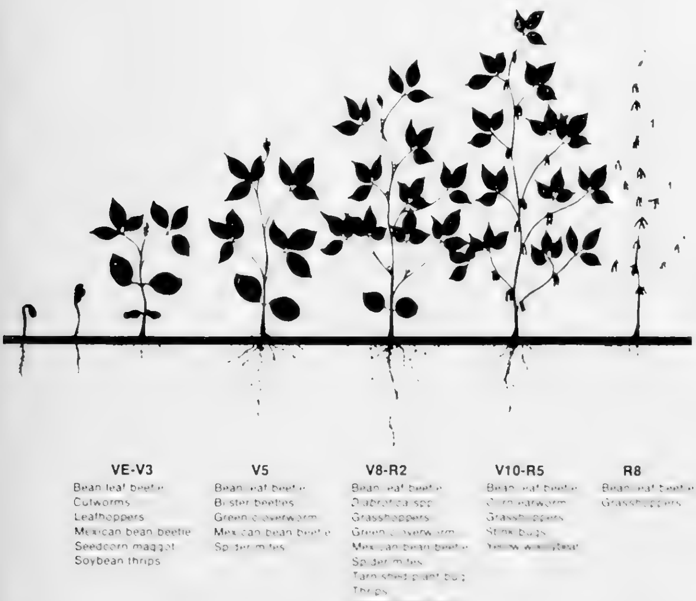
Managing Soybean Insects

A very informative publication, "Soybean Insects: Identification and Management in Illinois," *University of Illinois Agricultural Experiment Station Bulletin 773* recently was published by Marcos Kogan and Donald E. Kuhlman of the Illinois Natural History and the University of Illinois. This profusely illustrated 58-page manual contains economic, ecological, and entomological guidelines that are intended to optimize effective, insect pest management practices for soybean production. Publication of the bulletin was made possible by a grant from the Illinois Soybean Program Operating Board.

Soybean in Illinois long has been thought to be somewhat free of major insect pests. Actually, insects can attack soybean through much of the growing season, and this crop that has become so important to Illinois' total economy should be monitored for pest insects. Soybean presently constitutes one-third of the state's annual cash farm income. This economic significance has made it important to manage soybean insect pests with greater consideration for the overall soybean insect complex.

"Soybean Insects . . ." is one response to this developing need. For the record, insect pest management programs are not developed hastily because of the complexity of interrelated issues. Kogan and Kuhlman synthesized the results of numerous research programs and experiences to establish their management guidelines applicable to Illinois. The supporting background can be traced to local, state, national, and international programs in which the Survey and the University of Illinois, plus several other institutions, jointly have participated.



Growth stages of a soybean plant with associated insect complexes (VE-V3 = seedling; V5 = early vegetative growth; R2 = full bloom; R5 = beginning seed; R8 = full maturity).

The guidelines established by the authors are aimed at a wide audience: growers, extension advisers, pest consultants, pesticide dealers and applicators, pest scouts, and farm managers. The bulletin's contents cover growth of the soybean, identification and biology of soybean pests, and the procedures for establishing a soybean pest management program. The succinct writing, the informative charts and figures, and the numerous color illustrations lend to a very readable format.

Persons desiring to purchase individual or multiple copies of this new publication may address their inquiries to the University of Illinois, Office of Agricultural Publications, 123 Mumford Hall, 1301 West Gregory Dr., Urbana, IL 61801 or call 217-333-2548.

Long-Term Ecological Research on Major Rivers

A 5-year, 1.3 million dollar grant from the National Science Foundation (NSF) for a Long-Term Ecological Research (LTER) Project has been awarded to Illinois' Natural History Survey, Geological Survey and Water Survey, all divisions of the Department of Energy and Natural Resources, and to Western Illinois University. The project is designed to study the biological processes in large rivers, specifically the Illinois and Mississippi. The study, contingent on the availability of funds and scientific progress, may last as long as 30 years.

Richard Sparks of the Natural History Survey is the principal investigator of the overall project. Other Natural History Survey staff members who will be involved in this new study are Ken Lubinski, Michael Wiley, Robert Costanza, Robert Gorden, and Paul Risser, Chief. They will cooperate with the co-investigators from the other institutions.

The Division of Environmental Biology of NSF began a new emphasis on long-term research in 1980. This was in response to the subtle pressures that human technology is imposing on many populations, plant and animal communities, ecosystems, and on the earth's biochemistry. It is anticipated that long-term ecological research on selected ecosystems will result in understanding them sufficiently to predict their responses to disturbances, and to aid in decision making on policy options, environmental assessment, resources management studies, and instruction of students.

The LTER Project awarded to the aforementioned institutions is one of only 11 funded throughout the U.S.A. and is the only one on river systems. The others include temperate forests, grasslands and prairies, a coastal marsh, the Okefenokee Swamp in Georgia, Wisconsin lakes, and the Jornada Desert in New Mexico. Primary considerations of NSF in the acceptance of the Illinois interinstitutional proposal were the willingness of the principal investigators to make long-term commitments, the continuity of leadership, institutional cost sharing, physical facilities, site integrity, lack of conflict in site use, and long-term agreement with site owners.

Survey scientists will begin their investigation of major river ecosystems at 3 selected sites: Pool 19 (Keokuk Pool) on the Mississippi; Pool 26 on both the Illinois and Mississippi, with research concentration on the reaches above and below the new dam; and the Peoria Lake portion of Peoria Pool, on the Illinois River. They will start sampling Pool 19 this year, Pool 26 in 1983, and Peoria Pool in 1984. Intensive sampling will be conducted on each pool every third year, while less intensive monitoring will be continued on all pools every year.

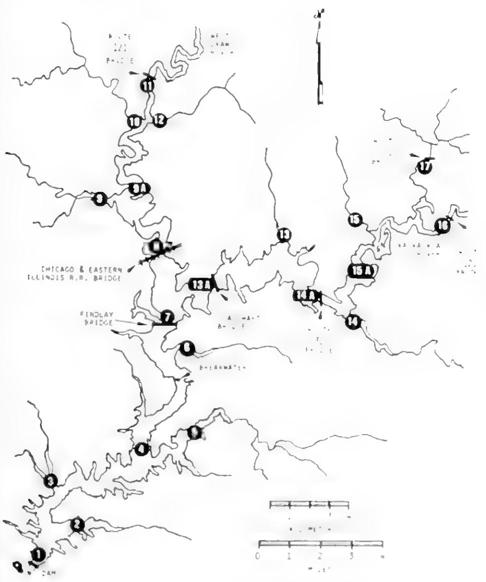
Pool 19 was selected because it is the oldest navigation pool on the Upper Mississippi River and is one of the most productive aquatic areas in the world. Peoria Lake is considered an experimental disturbed area on which the Surveys have good statistical data. Pool 26 provides an opportunity to study the ecological effects of a new navigation dam. This will be the first time that ecological data have been systematically gathered before, during, and after construction of a new navigation impoundment on the nation's largest river.

The Survey scientists have developed several predictions regarding effects of disturbances (both natural and man-made) on the plants, animals, and vital processes occurring in river ecosystems.

The data gathered during the LTER Project will allow testing of these predictions and will form a substantial basis for developing environmental assessment procedures and for promoting management of the Illinois and Mississippi and other large river systems in the nation.

Mercury Contamination Problem at Lake Shelbyville

Investigators in 1974 found that the muscle tissue of largemouth bass from Lake Shelbyville contained concentrations of mercury in excess of the 0.5-ppm limit set by the U.S. Food and Drug Administration. These fish are near the top of the aquatic food chain, and thus the occurrence of high mercury concentrations in their tissues was indicative of mercuric contamination at lower trophic levels and quite probably in the lake itself. Because Lake Shelbyville and its watershed are located in a prime agricultural setting with little industrialization, finding excessive mercury concentrations was unusual. A 3-year study to determine the cause, extent, and prognosis of the mercury contamination problem was initiated by former Survey analytical chemist Kenneth E. Smith and his associates and completed by present Survey chemist Susanne G. Wood and her associates.



Map of Lake Shelbyville (Shelby and Moultrie counties) showing sampling sites during mercury study.

Lake Shelbyville was formed by damming the Kaskaskia River near Shelbyville, Illinois. The water was first impounded in 1969 and reached the calculated, normal pool level in 1970. For the purpose of the present study, 17 sampling stations were established in 1977 and 4 more in 1979 for the collection of water, soil, sediment, zooplankton, and clam samples, and 5 species of fish. Eight stations were at mid-lake, whereas the other stations were located on tributaries and creeks near their confluences with the lake.

The mercury concentrations in zooplankton, clams, and most fishes analyzed were within the range of natural abundance for unpolluted areas of the U.S.A. Comparisons of the mercury concentrations in fishes over the 3-year period indicate decreasing trends for gizzard shad, bluegills, largemouth bass, and walleyes. If mercury concentration data for largemouth bass and walleyes collected in 1974 and 1975 are included, the decreasing trends for these 2 species are even more striking. However, the mercury concentrations in carp increased during the 3-year period. Note that this species scavenges decaying vegetation, which is known to contain fairly high concentrations of mercury, in bottom sediments.

The planting of mercurially treated wheat and oats in the Lake Shelbyville watershed area during the 1950's and 1960's has been ruled out as a source of mercury contamination. Both the frequency of use of such treated seed and the quantity used were insufficient to cause a significant increase over the natural abundance level of mercury in the soils. Furthermore, in the lake itself there was no mercury concentration pattern implicating any particular station or area of the lake as the site responsible for the contamination. Thus, neither a point source nor a more generalized area source for the mercury contamination in Lake Shelbyville could be identified.

The typical conditions of highly organic sediments and submerged plant debris, both of which contribute readily to the cultivation of microorganisms capable of methylating and thus mobilizing mercury, are present in the lake. As a result, the bio-

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amplification of mercury in the Lake Shelbyville ecosystem has proceeded in an orderly fashion corresponding to increase in trophic levels of the organisms, namely zooplankton < clams < gizzard shad < bluegills < carp < largemouth bass < walleyes.

Thus, the suggestion that the source of mercury in Lake Shelbyville's ecosystem may be a secondary consequence of damming has considerable credibility. It is well known that the bulk of the mercury in soils is absorbed onto fine particles, especially the fine particles with high organic content, and these are readily suspended and swept along with flowing water. The rate of flow decreases as river or creek becomes lake, and much of the suspended particle load is deposited. Even more convincing evidence of high mercury content in suspended particulate matter is provided by the filterable sediment data.

Approximately half of the collected water samples contained mercury levels below the detection limit of the analytical instrument. For the remaining samples, there were no significant differences in mercury concentrations between stations or years throughout the study period. Because the water samples were not filtered, the small amount of mercury present in the samples, while somewhat above the 0.05-ppb limit for freshwater aquatic life set by the U.S. Environmental Protection Agency, may be related to the presence of particulate sediment matter.

Soil, littoral zone sediment, bottom sediment, and sediment core samples contained mercury concentrations well within the range of natural abundance. Nevertheless, the soil samples collected near the lake shoreline at tributary mouth stations contained 2- to 6-fold higher mercury concentrations than those collected at remote watershed sites. Filterable (runoff) sediment samples, however, contained mercury concentrations well in excess of the natural abundance and 3- to 10-fold greater than the concentrations in littoral zone or bottom sediment samples; these findings are probably reflections of the size of the filterable sediment particles and their concomitant greater affinity for mercury adsorption.

It is now known on the basis of this study and several similar studies that new impoundments undergo periods of extensive biological and chemical changes characteristic of the conversion from a terrestrial to an aquatic ecosystem. The mercury in soils both inundated by the impoundment and carried into the impounded water is generally in an immobile (inorganic) state. Decaying flooded vegetation and other organic matter contribute to the growth of microorganisms capable of mobilizing the mercury present in the soils. Bioaccumulation then occurs. The problem period usually encompasses the first 3-5 years after impoundment and is followed by a period of subsidence until system levels have stabilized. At this stage the impoundment is no longer "new."

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New Fern Hybrid Found in Illinois

The ferns and fern allies of North America are well known, thanks to an enthusiastic host of amateur and professional botanists who have scoured the countryside in search of these delicate and interesting plants. It is indeed rare to find a new species or range record that has gone unnoticed, but recently Survey botanist Robbin Moran discovered a new undescribed fern from northern Illinois.

The new fern is a member of the genus *Cystopteris,* the bladder ferns. Perhaps the most interesting aspect of this fern's biology is that it is of hybrid origin between the bulblet bladder fern and Mackay's bladder fern. The hybrid has been given the name Illinois bladder fern, since it was first found in Illinois.

The hybrid appears intermediate when compared with its parents. One parent, the bulblet bladder fern, produces fleshy bulblets 5–10 mm in diameter on the underside of the leaf. These bulblets drop from the leaf when mature and vegetatively grow into a new plant. Mackay's bladder fern does not produce bulblets. In the hybrid, the bulblets are small and scaly rather than large and fleshy. The leaf stalk of the hybrid is darkened and brittle, a character acquired from the second parent. Overall, the shape of the leaf blade is intermediate between those of the two parents. These intermediate characteristics first led to the suspicion that the plant was of hybrid origin. Chemical studies further showed that the hybrid contained phenolic compounds that were additive with respect to the unique phenolic compounds present in both parents.

Moran found that the new fern existed in two different forms: plants with three sets of chromosomes and plants with six sets of chromosomes. When first formed, the plants have three sets of chromosomes; these plants produce aborted unviable spores and are therefore sterile. However, through quirks in the meiotic cell division process, viable spores are occasionally produced. These spores may eventually double their chromosome number, a process known as polyploidy, and form plants with six chromosome sets. The new plants, unlike their progenitors, are able to produce normal spores and are fully fertile. Thus, they

Herbarium specimen of the Illinois bladder fern. (Photo by Survey Photographer Les Woodrum)

can reproduce themselves and expand their range independently of their parents.

The hybrid and its two parents are found on rock cliffs and tallus slopes. A search of specimens from several Midwestern herbaria has revealed a total of seven locations for the Illinois bladder fern. The locations are centered around the Driftless Area where Illinois, Wisconsin, Minnesota, and Iowa meet. Two Illinois locations are known for the Illinois bladder fern, one in Lee County and the other in Winnebago County. Moran plans research trips to some of these sites to gain more knowledge concerning the biology of this interesting fern.

Alfalfa Weevil Fungal Infection

The fungus, *Zoophthora phytonomi,* has been recognized for many years as the most important natural control agent of the clover leaf weevil, *Hypera punctata.* In 1973 in eastern Canada researchers found an identical *Zoophthora* pathogen in larvae of the alfalfa weevil, *Hypera postica.* This fungus was first discovered in Illinois by Survey entomologists P. L. Watson, R. J. Barney, J. V. Maddox, and E. J. Armbrust in Washington County on May 9, 1979.

They conducted a study to determine whether humidity or photoperiod (the relative lengths of alternating periods of light and dark) was responsible for sporulation (the formation of spores) by *Z. phytonomi* in alfalfa weevil larvae. This study was also designed to determine the method and duration of the infection.

Alfalfa weevil larvae were collected from four Illinois counties and one Kentucky county and were held in cartons containing freshly cut alfalfa that was changed daily. Every 2 hours for 24 hours eight dead larvae were randomly selected and were placed in covered petri dishes containing non-nutrient agar, which served to maintain a high humidity in the petri dishes. Four larvae from each 2-hour period were kept in a 16-hours-light-and-8-hours-dark photoperiod at 78°F, while the other four dead larvae were kept in the reverse photoperiod of 8 hours of light and 16 hours of darkness. Every 2 hours the dishes were checked for the typical whitish halo of conidial spores surrounding any of the larvae, indicating that sporulation had occurred.

After the entomologists had determined the timing of the sporulation, healthy alfalfa weevil larvae were exposed to the infectious spores by two methods. Twenty potentially sporulating dead larvae were placed singly on agar disks, and each was inverted over a healthy larva of the second or third instar (a stage in an insect's life) in a separate petri dish. This method was called the shower technique. In the other treatment, fungus spores were directly applied to the alfalfa weevil larvae, and this was called the contact technique. Ten larvae in the second instar and ten in the third were exposed to spores in each treatment. All larvae were exposed to spores for 24 hours, and an alfalfa leaflet was provided to each larva for food during the exposure. Larvae were transferred after 24 hours to separate rearing cages to complete their development at 78°F.

The researchers found that the photoperiod had no effect on the sporulation of *Z. phytonomi* in alfalfa weevil larvae. Other scientists had found that peak sporulation of the related fungus *Z. gammae* occurred between 4 and 8 hours after being placed in chambers having high humidity. The same was shown to be the case with *Z. phytonomi,* since the mean time required for dead larvae to produce conidial spore showers was 6.8 hours regardless of the photoperiod used.

Other researchers had found that peak sporulation of the fungus *Z. gammae* occurred in the early morning hours. Most of the sporulation in this study also occurred between midnight and 4 a.m. The entomologists concluded that high humidity was the primary factor initiating sporulation by *Z. phytonomi* in alfalfa weevil larvae. They believe that sporulation by *Z. phytonomi* under field conditions probably occurs in the early morning hours when the relative humidity is the greatest. High humidity would protect the spores against rapid drying and inactivation and is conducive to further infections, as has been suggested by other scientists.

Infected alfalfa weevil larvae died within 7 days regardless of the method of

infection. The rate of infection of larvae that were exposed to the spore shower was 95 percent. The contact technique produced infection in 25 percent of the larvae. However, no matter which infection method was used, all larvae exposed to spores as second-instar larvae produced infectious spores, while those exposed as third-instar larvae produced resting spores.

The finding that infectious or resting spores were formed, depending on the larval instar infected, was an unexpected result that may explain the timing of the fungal infection of alfalfa weevil larvae in the field and the quick occurrence and departure of the infection from the field in the spring.

Results of Illinois Natural History Survey research and information on how to apply these results are published as Survey Bulletins, Biological Notes, and Circulars, available free to Illinois residents. (Photo by Survey Photographer Les Woodrum)

Natural History Survey Publications Available to You

The mission of the Illinois Natural History Survey is to study and investigate the living natural resources of the state, prepare printed reports, and furnish information on the protection and conservation, development, and use of these resources. Survey scientists recognize that the final step in the research process is the publication of the results of research.

Consequently, Survey scientists write many reports each year, most of which are published in scientific and technical journals and some of which are published by the Natural History Survey itself. Most of these publications are available free of charge to residents of Illinois and to scientists and research organizations outside of Illinois. In the past year the Survey has published a 459-page monograph on 4 years of interdisciplinary investigations on the ecology of a power plant cooling lake and shorter reports on the life history of a small fish, the Tennessee snubnose darter; effects of ingested lead-iron shot on mallards; and the population, ecology, distribution, and abundance of Illinois pheasants. In the preceding year one Survey booklet was titled *Observing, Photographing, and Collecting Plants.* A 20-page brochure about the Natural History Survey has recently been published, and a list of Survey publications is also available.

To receive the list of publications, to request a publication, or to have your name placed on the mailing list for *Illinois Natural History Survey Reports,* write to Dr. Paul G. Risser, Chief, Illinois Natural History Survey, Natural Resources Building, 607 East Peabody Drive, Champaign, Illinois 61820.

Insecticide and PCB Levels in Woodcocks, Robins, and Mourning Doves

Levels of heptachlor, heptachlor epoxide, aldrin, dieldrin, p,p′DDE, and polychlorinated biphenyl (PCB) have been determined for muscle, liver, heart, brain, and fat samples from 15 woodcocks, 6 robins, and 8 mourning doves from east-central Illinois collected in 1979 and 1980 during an ongoing woodcock population ecology study by wildlife ecologist William R. Edwards and his associates.

Although pesticides were recorded at generally low levels, consistently lower than 1 part per million (ppm), all woodcocks were found to contain one or more of the six compounds assayed; the average woodcock had 2.4 of the six compounds. The same was true for robins, with an average of three compounds per individual, and mourning doves, with an average of 2.4 per individual. Of all 107 samples assayed, 3 (2.8 percent) contained heptachlor, 54 (50.5 percent) contained heptachlor epoxide, 1 (0.9 percent) contained aldrin, 86 (80.4 percent) contained dieldrin, 22 (20.6 percent) contained DDE, and 9 (8.4 percent) contained PCB's.

In general, it appeared that the insecticide loads of woodcocks and mourning

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doves were similar, whereas those of robins showed more individuals with heptachlor and heptachlor epoxide and fewer with dieldrin. The only incidence of aldrin occurred in a robin. Robins may have had a higher incidence of PCB's; however, sample sizes were small and the results cannot be considered conclusive. On the basis of food habits, the researchers anticipated that the insecticide loads of woodcocks and robins would be similar and that of mourning doves somewhat different, as the former eat large quantities of earthworms and the latter are considered largely seed and grain eaters. At this time the scientists can offer no basic explanation for the apparent anomaly in the insecticide loads of woodcocks, mourning doves, and robins from east-central Illinois.

Chlorinated hydrocarbon insecticides have been commonly used to control soil insects in corn since World War II. However, DDT has not been used extensively since the late 1950's. The use of aldrin declined after 1966 and effectively ended in 1976, as did that of heptachlor in 1978. Data from several studies in Illinois and elsewhere suggest that the incidence of DDE, and probably other chlorinated hydrocarbon residues, is declining in wildlife. This decline is probably not true of PCB's. Survey wildlife ecologists will continue to monitor pesticide levels in woodcocks and associated bird species.

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Illinois Agriculture and the Declining Survival Rate of Pheasant Chicks

The intensive use of land for agriculture in Illinois generally has caused declines in the abundance of wildlife. However, for many species the actual mechanisms of such declines are unknown. Wildlife ecologist Richard E. Warner is conducting a long-term study of interactions between agriculture and ring-necked pheasant populations in Illinois. The findings of this research may illustrate the effects of declining habitat for a variety of grassland species.

For example, information collected for pheasant populations in Illinois suggests that over the past three decades the survival of pheasant chicks has declined. The average number of eggs hatched per nest has remained relatively constant during this period. Yet the average number of chicks observed per brood along standardized routes near Sibley (Ford County) has declined from 6-9 during 1948-1954 to 6-7 during 1955-1959, 5-6 during 1960-1964, approximately 4 during 1965-1969, and 3-4 during the 1970's. Moreover the Illinois Department of Conservation's brood counts corroborate these trends for most of this state's pheasant range.

Pheasant chick requires insect diet during the first few weeks of life. Without it, there is little chance of survival. (Photo by W. E. Clark)

The decline in the survival rate of pheasant chicks may be a significant limitation for the abundance of pheasants in Illinois. Increased mortality of young pheasants appears to be related to the expanded production of corn and soybeans, with associated clean farming practices. Pheasant chicks require a near-total insect diet during the first few weeks of life. Traditionally, broods have foraged for insects in oat stubble and forage legume fields; such fields are nearly absent on the landscape in many parts of Illinois today.

It is plausible that the reduction in both quality and quantity of forage habitat for pheasant broods is in part related to the decline in pheasant numbers. Because a variety of grassland birds forage for food in similar habitats, the pheasant chick may be representative of a wide-spread decline in the survival of young birds in Illinois.

Rare Wasp Found

The wasp family *Rhopalosomatidae* has been found to occur in several states neighboring Illinois, but until now has not been recorded from Illinois. Three specimens were collected near Mahomet.

Champaign County, by former Survey entomologist Milton W. Sanderson in 1968 and recently were recognized in the Survey's Insect Collection by Survey entomologist W. E. LaBerge and identified as being *Olixon banksii* (Brues).

This wasp is about ¼ inch long, pale colored, has very short wings and cannot fly, and has extremely long hind legs. The females of *Olixon* pursue crickets, especially the common small brown or black ground crickets of the genus *Nemobius*, and lay an egg on the surface of the cricket. The larva which hatches from this egg remains attached to the cricket, feeding as an external parasite and eventually dropping to the ground to pupate and emerge as an adult wasp. The cricket begins to die and dies as the wasp larva reaches maturity.

It is likely that *Olixon* occurs throughout the state of Illinois, especially in wooded areas, although it has been collected only this one time. Its small size, inability to fly, and other habits make it easily overlooked by entomologists. The wasps were collected by Sanderson in pan-traps placed with their rims flush with the surface of the soil in a wooded area. About an inch of water with a drop of detergent is placed in the pan and insects that inadvertently drop into the water are unable to escape because of the lowered surface tension.

Because of its habits, *Olixon banksii* must be considered to be a beneficial insect, although of such rarity as to be not of great importance. How common or rare it actually is, however, has never been assessed.

Rare wasp, *Olixon banksii* (Brues), identified in Survey's Insect Collection. (Photo by David Voegtlin)

Water Resources: Assessment of Biotic Integrity

The surface waters of the United States absorbed pollutants as well as other impacts of a developing society for several centuries before signs of degradation could no longer be ignored. A "dilution-is-the-solution-to-pollution" approach to waste disposal prevailed and typically resulted in grossly polluted water and associated losses of aquatic resources (particularly fishes). By the mid-twentieth century, early legislative efforts were initiated to halt and perhaps reverse this ominous trend.

Passage of the Water Quality Act Amendments of 1972 stimulated many efforts to monitor the quality of water resource systems and to control a host of societal effluents. The primary approach was to restore the chemical quality of water; it was presumed that improvements in biological quality would follow close at hand. In many cases streams were viewed as conduits for the transport of water and water development schemes rarely included assessments of biological impacts. As a result habitat quality and thus biotic integrity continued to decline in many areas despite massive expenditures of funds. Ironically, man's "technological solutions" to water resource problems sometimes contributed to declines in biotic integrity (e.g., chlorine toxicity in the effluent of sewage treatment plants).

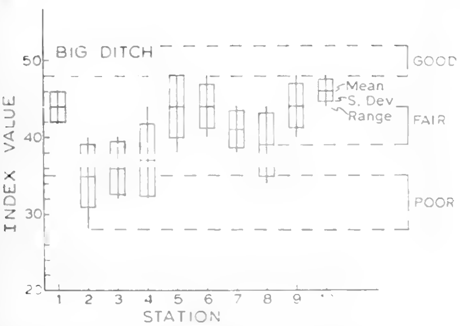
Recent legislation such as the Clean Water Act of 1977 clearly called for a more refined approach when pollution was defined as "the man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water." Despite this refinement, regulatory agencies have been slow to replace the classical approach (uniform standards focusing on contaminant levels) with a more sophisticated and environmentally sound approach.

The integrity of water resources can best be assessed by evaluating the degree to which waters provide for beneficial uses. Important uses as defined by society may include water supply, recreational, and other uses as well as the preservation of future options for the use of the resource.

Since an ability to support a balanced biotic community is one of the best indicators of the potential for beneficial use, sophisticated monitoring programs should seek to assess "biotic integrity."

During the past few years, James R. Karr, an affiliate of the Survey's Aquatic Biology Section and Professor in the Department of Ecology, Ethology, and Evolution at the University of Illinois, has conducted research supported by the U.S. Environmental Protection Agency that has resulted in the development of a new system for monitoring the quality of a water resource. This system directly evaluates biotic integrity through the use of a special index, a multi-parameter model similar to the multi-parameter assessments used by economists. The core of the system involves evaluation of about a dozen attributes of fish assemblages in streams. Parameters include species composition and richness as well as several measures of trophic structure (food habits) in the assemblages. Additional parameters include prevalence of disease and hybridization.

Fish are collected for evaluation of effects of pollution in Big Creek, Hardin County. (Photo by James R. Karr)



Change in Index of Biotic Integrity along a stream gradient (Big Ditch, Champaign County) from headwater (Station 1) to downstream (Station 10). Stations 2 to 4 are low because of sewage input between stations 1 and 2 and stations 7 and 8 are depressed because of the poor quality of habitat conditions. Generally low values (no good or excellent conditions) reflect the general agricultural land use in the Big Ditch watershed.

Fish are a logical group for assessment of biotic integrity because their natural histories are well known, they are relatively easy to identify, the general public can relate to statements about conditions of the fish community, and the results of studies of fishes can be directly related to the fishable waters mandate of the U.S. Congress.

The "Index of Biotic Integrity" can be used to rapidly and inexpensively assess the extent of water resource degradation. Where impaired use is suggested, a more complete monitoring program can be implemented to search for the causative agent or agents. With this approach, geographically extensive and expensive monitoring programs can be scaled down at considerable savings to society.

Researchers and planners from throughout the United States and a number of other countries have expressed interest in the Index. Testing and evaluation of the Index continues this year under a grant from USEPA. For more information contact James R. Karr, Department of Ecology, Ethology, and Evolution, 102a Vivarium, (217) 333-1633.

Survey Speakers Available

In the spring of 1981, a Survey Speakers' Bureau was organized and researchers were asked to volunteer their services to the project.

Members of the Survey staff volunteered their services, agreeing to speak on a variety of subjects, among which are Water Pollution, River Biology, Integration of Aquaculture with Agriculture, The Rose Family, Illinois Wildflowers, Natural Areas, Butterflies in Illinois, Research on Deer, and a general talk on the Illinois Natural History Survey.

Anyone wishing to engage a speaker should contact the Speakers' Bureau at (217) 333-6882.

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Witches' broom on honeysuckle. Upper photo is appearance in summer (Photo by Les Woodrum) and lower photo is appearance in winter (Photo by David Voegtlin).

Alien Aphid Finds a Home

An aphid thought to be a native of Eurasia has been rapidly making itself at home on many of the species and hybrids of ornamental honeysuckles planted throughout the north-central states. The feeding of this aphid, *Hyadaphis tataricae* (Aizenberg), causes severe deformation of the growing tips, which are commonly called witches' brooms.

It was first found in the Montreal, Canada area in 1976. The first record in the north-central states is from Lake County, Illinois in the fall of 1979. The distribution and spread of this aphid was studied in detail during 1981 by David Voegtlin of the Illinois Natural History Survey. The aphid is very efficient at distributing itself and the movement of infested plants, such as nursery stock, is probably a major factor in its rapid spread. As of the fall of 1981 the aphid was found in Ohio, Indiana, Michigan, Wisconsin, Minnesota, Iowa, and Nebraska, as well as Illinois. The insect probably will continue its spread until it covers the area in which the host honeysuckles have been planted.

At present the following species and hybrids of honeysuckle have been found to be attacked by this aphid: *Lonicera tatarica, L. bella, L. minutiflora, L. muendeniensis, L. muscaviensis.* None of these is native to North America and planting any of these is a guarantee of future problems with this aphid. Most nurseries throughout the infested area are no longer stocking these because of the problem with this plant louse.

H. tataricae is specific to honeysuckles and will not feed on any other plants. The

witches' brooms can be of two types, pendulus or upright clusters. Both are formed by masses of increasingly small leaves which are folded in the middle with the upper side in, forming a pocket in which the aphids are located. To find the aphids one must open these folded leaves. The witches' brooms are a lighter color than the normal leaves and when the infestation is very heavy the outer parts of the plant take on a different hue. In late August and early September the witches' brooms die while the normal leaves remain green. After the regular leaves drop off in the fall, the damaged areas are highly visible, often retaining the tiny leaves throughout most of the winter.

Voegtlin says control can be obtained through the use of systemic insecticides. Local agricultural extension agents can recommend the current acceptable insecticides for use against the aphid. Spraying will have to be done often throughout the year as there is so much wild and planted honeysuckle during the summer that a continual supply of winged aphids reinfest the plants.

"Gob" Piles To Be Reclaimed

If you have ever driven on I-55 south of Joliet or on US-51 north of Bloomington-Normal, you may have noticed some large, conical, red and grey waste-rock piles. These "gob" piles are the remnants of the state's first industrial-scale coal mining district, the Longwall District, opened after the Civil War.

These mines had access to the booming Chicago industrial market, and in 1882 were producing 34 percent of the coal mined in Illinois. After 1906, however, their production was exceeded by the very large, more mechanized mines in southern Illinois. By 1924, their production dropped to 1 percent of the state's total. Finally, the Great Depression of the 1930's closed the era of the longwall mine.

Over the years, a number of factors have excited interest in the reclamation of these mine sites; the very prominence of the gob piles, the large acreages of many, their proximity to towns, their nuisance and harmful features, and, recently, the creation of the Abandoned Mined Lands Reclamation Council to clean up such problem areas in the state. The Council has granted a contract to the Illinois Natural History Survey to study these longwall waste piles to determine what kinds of reclamation are practical.

The mines of the Longwall District generally lie within 20 miles of the Illinois River between Morris and Peoria. Almost all old longwall mines in Illinois are found in this district; it is the only place in the nation where large tonnages of coal were mined by this method.

The longwall mining method can be compared to a spoked wheel. A vertical hoisting shaft — like the axle bore — entered the coal from the surface. Radiating from the shaft, like hollow spokes through the shaft pillar and the coal being mined, were permanent tunnels called the "main entries." The main entries carried coal from the "working face" to the hoisting shaft and were extended as the coal was mined. The working face was the rim of the wheel where the coal was mined.

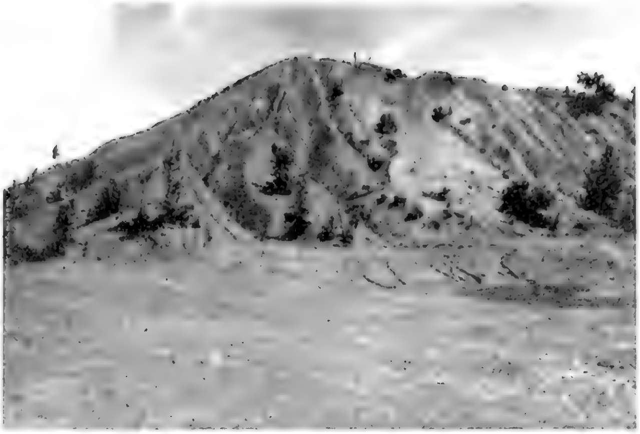
The miners worked crouched in the 3-foot-high seam opening. But along the main entries, they took down about 4 feet of roof rock to make 7-foot high ceilings and gave themselves and their mules headroom. Because all the coal was removed in the mine the rock overhead inevitably settled down into the mine openings. To keep the main entries open, they often had to clear falls and settlements out and haul the rock to the surface.

The largest of the gob piles are 180 to 190 feet high and cover 25 to 30 acres. Rains wash and gully their bare sides, carrying away mud and chemicals weathered from their pyritic shales. Grasses, weeds, and trees have not been able to take root on the steeper slopes of most of them.

It is the purpose of the Natural History Survey to assess the feasibility of revegetating the mined areas. Botanist Diane Szatoni and her associates will be examining the plant species that can survive on the barren gob piles and provide needed wildlife habitat.

During June and July 1982, an extensive literature review was begun. Special attention was given to plant species selection, soil amendments, and reclamation

"Gob" pile in the Longwall District.



practices of the high plateau regions, the northern Great Plains, and the eastern bituminous coal fields, where ecological conditions may be similar to those of the north-central Illinois mines.

In addition, a preliminary inventory of plant species that occur on the gob piles during the spring, summer, and fall was begun.

Aquaculture Workshop Held

The importance of the correct selection of fish and other components to suit the aquaculture system was emphasized by Dr. William Lewis, Southern Illinois University, at a workshop, Aquaculture-Possibilities for Development in Illinois, held recently at Levis Center on the campus of the University of Illinois.

Fish which grow rapidly, survive cold winters, have a favorable dressed weight to live weight ratio, feed well on artificial feeds, and have a good market potential are most desirable. New species may have to be selected or developed. Genetic techniques are being modified which may enable scientists to develop and clone fish with desirable traits especially adapted to aquaculture systems, according to David Philipp, Survey fisheries biologist.

Although approximately 12,000 miles of streams and rivers, more than 240,000 acres of lakes and impoundments, and over 50,000 acres of reservoirs are located in Illinois, fewer than 2,500 acres are currently used for aquaculture production. Thousands of acres of marginal land in southern Illinois could be converted to aquaculture impoundment systems as well.

Marketing potential for fish and fish products is highly competitive with marine and freshwater commercial fisheries and with aquaculture products from the southern U.S. Creative production methods using thermal effluents, confinement systems, agricultural waste products as feeds (see Survey Reports, May 1980), and multiple cropping, coupled with shorter transportation routes, may make Illinois aquaculture products more competitive.

A study by Dr. Randy Westgren and Professor Margaret Grossman, University of Illinois, has shown that problems in the legal and regulatory environment in Illinois aquaculture are due to uncertainty and complexity in state laws brought about by a lack of recognition of aquaculture as a viable form of agriculture. Relatively minor modifications in both statutory and regulatory areas could result in an environment favorable toward aquaculture. It is also clear that the economic infrastructure must become familiar with the potential value of aquaculture before funds for facilities and equipment will be available to the producers from lending agencies (see Survey Reports, December 1980).

Several producers of catfish and other aquaculture products described problems which range from maintenance of valuable brood stock to oxygen depletion in ponds. In spite of these problems, they have maintained successful aquaculture operations for several years.

The future of aquaculture in Illinois seems dependent upon the wise use of

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genetically adapted fish to suitable aquatic ecosystems; efficient feeding, harvesting, processing and marketing methods; recognition and acceptance by selected agencies; and modification of certain laws and regulations.

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Black Cutworm Pheromone Trapping

The black cutworm, *Agrotis ipsilon,* can be a serious pest of seedling corn in the U.S. corn belt. Damaging larvae are thought to originate from eggs oviposited by female moths in fields in early spring before the crop is planted. Many scientists believe that the moths that lay these eggs immigrate to the corn belt from southern latitudes each spring. Consequently, early-season moth detection is important, especially since pest outbreaks tend to be very sporadic.

Two Survey researchers, Eli Levine and William G. Ruesink, along with several other researchers from Ohio, Iowa, Indiana, and Missouri, recently conducted a study on the trapping of black cutworm (BCW) moths.

Once the sex pheromone (a pheromone is a mixture of chemicals released by the female moth to attract a mate) system of this moth was identified, the researchers set out to determine if synthetic-pheromone (SP)-baited traps would improve early-season moth detection capabilities compared to the previously used black light (BL) trap (light used as a lure). Field studies were conducted in five major corn-producing states (Illinois, Indiana, Iowa, Missouri, and Ohio). In each state, SP traps and BL traps were placed in the proximity of corn or soybean fields and were examined for captured BCW moths at weekly intervals.

The results of these studies showed that SP traps were a more sensitive monitoring tool than BL traps during the period when it is most important to monitor moth flight activity; namely, between early April and early June. Through the first week in June in each state, males were caught significantly sooner (on average, three weeks earlier) and in significantly greater numbers in SP traps than in BL traps.

Researcher Eli Levine examines two male moths caught in black cutworm pheromone trap (Photo by Les Woodrum).

From a pest management standpoint, it is important to know if female activity is closely related to that of males as measured by SP traps during early season. Evidence suggesting that SP trap catches of males better reflect early female egg-laying activity than do BL catches of females (SP traps catch only male moths, whereas, BL traps catch both males and females) was provided by a concurrent study where the reproductive condition of females from BL traps was examined. In this study, it was found that older mated females were the dominant forms during the early season. On the basis of this finding, it was concluded that females had deposited significant numbers of eggs preceding their capture in BL traps, and therefore, the first capture of a male in a SP trap would probably serve as a useful reference point to denote the start of egg

laying in the central Corn Belt. A BCW development model (created and refined by Steve Troester, another Survey researcher), initiated with this information, could then be used to predict the occurrence of damaging larvae. This model will provide corn producers with information on the time (date) when they should actively scout their fields for this pest. Indeed, Illinois, Iowa, and Ohio are already using data from SP traps as a basis for computer prediction models.

Winterizing Roses

Every year people lose many rose bushes during the winter. Survey botanist Ken Robertson observes that there are several ways to eliminate or minimize this problem: 1) don't grow roses, 2) plant new roses every spring, or 3) perform some preventive maintenance. These notes have been prepared for those who select alternative number 3.

Several basic types of roses are commonly grown in Illinois — hybrid teas, grandifloras, floribundas, climbers, tree roses, and shrub roses. The vast majority of cultivated roses have beautiful but anemic stems that are grafted onto the roots of vigorous wild-type roses. This graft, or bud union, results in a knuckle-like knot of wood at the base of the stem, and the joint is very vulnerable to cold temperatures. When planting rose bushes in most parts of Illinois, the roots should be positioned so that the graft joint is located approximately 1 inch below the surface of the soil. This layer of soil will help protect the most cold-sensitive part of the rose bush from winter temperatures.

In addition, most roses will benefit from additional winter protection. Robertson stresses that NONE of the following should be done until AFTER the plants have gone domant and there has been a HARD, killing frost; if this warning is not heeded, more harm than good will be done to the plants.

To protect hybrid tea, grandiflora, and floribunda roses, tie the canes together and cover the lower part of the plant with a mound of soil (or grass clippings) to a height 6″-8″. Do NOT obtain this soil from the immediate vicinity of the rose bush since this will damage the plant's roots. Then, cover the rest of the lower part of the plant with straw, hay, or styrofoam rose caps or cones. The plant can be dusted or sprayed with rose pesticides before making the mound. Plants may also be pruned back somewhat before covering, but it is important not to prune very heavily because the ends of branches are killed back during the winter, and if the plants have been closely pruned, this can damage major stem branches.

The common climbing roses do not need special winterizing, although the base of the plant can be protected with a mound of soil, as outlined above. Some of the fancy varieties are rather tender. To protect these, tie the canes together and bend them over and use stakes to hold the canes parallel to the ground. Then cover the canes with a layer of soil and/or hay.

The techniques outlined above for hybrid teas and climbers can be used for some shrub roses, while other shrub roses require no winter protection at all. Tree roses require rather specialized winter pro-

Beautiful roses are ample reward for the conscientious grower (Photo by Ken Robertson).

tection, and information on how to do this is available at garden centers and in rose care books.

As Robertson says, roses are beautiful plants and have an aura of mystique about them, having been cultivated and revered since Classical times. However, roses are not for everyone's garden. Rather, like an expensive sports car, they are for people willing to give them considerable attention. These people find their efforts are more than amply rewarded.

Study Begun at Jade Acres

A study to determine the feasibility of creating a rural center of appropriate energy and agricultural technologies has been initiated by the Illinois Natural History Survey. Offered as a gift to the State of Illinois by Dave and Jane Fletcher, the site for the proposed Illinois Appropriate Technology Research and Education Center is at Jade Acres near Salem, approximately five miles from I-57 at the Alma exit.

The 50-acre rural site is representative of the hilly, sparsely wooded, marginally agricultural land typical of southern Illinois. Surrounded by a 7-foot chain link fence with a large brick and iron gateway, the farm offers an impressive and beautiful site for research and demonstration. Extensive security measures protect the house and buildings.

The 9,000-square-foot English Tudor mansion, constructed in 1976, is well built and well appointed. Many construction changes added to conserve energy have effectively reduced heating and cooling costs. The home will be available for multiple usage, including conference center, library, laboratories, and offices. Additional outbuildings include a storage and loafing barn, milking barn, kennels, smoke house, and summer kitchen. The latter is well equipped for food processing activities. The estate has an in-house computer and tools and equipment for farming, gardening and workshop.

For the past six years, the Fletchers have developed the farm on organic principles. Pastures, woodlots, gardens, orchards, and pond banks have been planted with a variety of biomass- and food-producing

The mansion at Jade Acres will offer facilities for the interdisciplinary research of the Survey (Photo by Mitch Beaver, Dept. of Energy and Natural Resources).

perennials. Also on site are a dairy goat herd, chickens, ducks, cows and honey bees.

The planned center will be an integrated system of energy and agricultural technologies which are efficient and effective for individual homeowners and small farms. Wind, solar and biofuels technologies will be coordinated with alternative agricultural methods, including permaculture, vegetation biomass, aquaculture and dairy goat production. Research in and modification of existing methods will be an important aspect of the center. A primary goal of the program is to demonstrate soft alternative appropriate technologies which are cost-effective on marginal lands.

A site director and advisory group are being sought for the feasibility study. Volunteers interested in working on the site in exchange for room, board, and valuable experience should contact: Mr. Dave Fletcher, R. R. #4, Salem, IL 62881, or telephone 618-548-4473.

Pheasant Hunting 1982-1983

The ring-necked pheasant is the most popular game species in Illinois. Both the hunting and nonhunting public consider the gaudy ringneck to be a symbolic and highly visible representation of the Prairie State's rich wildlife heritage. Thus, it is not surprising that recent declines in pheasant numbers have captured the attention of the public.

Indeed, not all has been well with Illinois pheasant populations in recent years. For example, from 1973 through 1978, the

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relative abundance of pheasants declined 84% range-wide in Illinois. Declines in numbers of pheasants during the late 1970's and early 1980's have been largely the result of unusually severe winter weather. The critical long-term factor, however, has been the destruction of habitat. As farms in Illinois have become increasingly corn-soybean enterprises, forage legumes and small grains — prime pheasant habitat — have become scarce on the agricultural landscape.

In spite of the relatively sparse numbers of pheasants at present, wildlife ecologist Richard E. Warner suggests that there are some factors hunters should consider in order to improve their success in bagging a rooster. First, hunters should be aware that the patterns of relative abundance and distribution of pheasants have changed substantially in Illinois over the past decade. Hunters who traditionally traveled to east-central counties should now consider arranging trips to Mason County, or northern counties such as Carroll, De Kalb, Kendall, Lee, Ogle, Stephenson, Will, Winnebago, or Woodford. Secondly, parties should seek permission to hunt on farms that still produce hay and small grains, and that have unplowed grain stubble and permanent vegetation remaining over winter. Lastly, Warner recommends that hunters be more persistent. In recent years, a high percentage of pheasant hunters put their guns away for the season after opening weekend. Often, however, the best pheasant hunting occurs later in the season, after the first snowfall and colder weather.

Researchers have concluded that the sport hunting of cock pheasants does not adversely affect reproduction by hen pheasants the following spring. Investigations have also shown that releasing pen-raised pheasants generally does not enhance self-maintaining populations. Illinois pheasants would benefit primarily from habitat improvements. The Illinois Department of Conservation offers programs to private land owners that will enhance wildlife populations on their land.

Agricultural land use policies will in the future largely contribute to the status of Illinois pheasants. In some regions of Illinois, the production of row crops has resulted in severe soil erosion. Crops that enhance or protect topsoil, such as grasses, legumes, and small grains, are relatively beneficial to pheasants. In general, pheasants and pheasant hunters would greatly benefit from agricultural policies and programs that would both mitigate soil loss, and prevent an oversupply of feed grains in the market place.

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Hold That Tiger!

In an effort to improve the balance between predator and panfish populations, increase the diversity of the angler's catch, provide a trophy fish, and increase the growth of stunted panfish populations, Survey researchers have introduced the tiger muskie into some small lakes and ponds of Illinois.

The northern pike, muskellunge, and their hybrid offspring, the tiger muskie, are among the predator species that have been used to complement the largemouth bass. All three of these fishes achieve greater maximum size than largemouth bass and are able theoretically to eat larger bluegill than are normally selected by bass. Because they are cool-water species they exhibit seasonal peaks in food consumption in the spring and autumn; thus, they may complement the feeding activity of the largemouth bass which feeds most heavily in midsummer.

The tiger muskie is a hybrid which has proven superior to both parents in many hatchery situations and possesses characteristics which also make it useful to the fishery manager. The tiger muskie is believed to be intermediate between parents in angling vulnerability and may therefore contribute to the harvest without being overexploited. Furthermore, there is evidence that the tiger muskie has a higher survival and growth rate than either parent and is more tolerant of high summer water temperatures often experienced in Illinois.

In 1982 aquatic biologists began a 3-year study to evaluate the impact of tiger muskies on the bass-bluegill combination in small impoundments. The study objectives are to determine the survival, growth, hooking mortality, food habits, and spillway escapement of tiger muskies as well as the impact of these large predators on bass-bluegill populations.

The value of the tiger muskie as a management tool will not be established until the end of the project, but some useful data have already been obtained. Most of the tiger muskie research is being conducted at Ridge Lake, a 15-acre experimental fishing lake operated by the Survey in cooperation with the Illinois Department of Conservation. The lake was stocked in the summer and autumn of 1981 with largemouth bass, bluegill, channel catfish and 150 eight-to-ten-inch tiger muskies.

At Ridge Lake, tiger muskies are quite vulnerable to capture by hook and line, but survival of hooked fish is reasonably good. Over 40 percent of the number of stocked tiger muskies were caught during the 1982 fishing season, but only 10 percent of these died as a result of the hooking experience. Good growth, indicated by an approximate doubling in length in one year, suggests that a bass-bluegill population can provide

Tiger muskie caught at Clinton measures 35 inches in length and weighs 10 pounds (Photo by Dennis Newman).

adequate forage for tiger muskies. However, the food selected by the tiger muskies is an important consideration. If largemouth bass are eaten frequently, the potential value of the tiger muskie will be greatly compromised.

The lake was opened to fishing in April of 1982 and remains open each year until October 15. Since all fishermen must pass through a single checkpoint to gain access to Ridge Lake, harvest data relevant to the tiger muskie research are easily obtained. Also, since Ridge Lake can be completely drained, it will be possible to collect precise survival and growth information on tiger muskies and associated species at the end of the projects. Two other impoundments, stocked with tiger muskies in September of 1982, will provide information on the food habits and bluegill population control capabilities of this species.

Effects on Economic Injury Levels Of Weed/Defoliation Interactions

Current integrated Pest Management systems rely on established economic injury levels for control decisions. Economic injury levels have been established for many soybean insect pests, but few are available for the major weeds, diseases, and nematodes; none exist that take into account the concurrent effect of multiple pests. The actual field situation, however, is one where many pests coexist and their effects are likely to be increased as a consequence of the multiple-pest interactions.

A major difficulty in establishing economic injury levels for multiple pests relates to the complexity of the experimental design necessary to measure the various interactions. For example, economic injury levels for defoliating insects alone are tested using a randomized complete block design with various levels of defoliation effected at various stages of plant growth. As another pest is added, the design changes to a split-plot and each new pest requires a new split. Not only does the design become cumbersome, but in the past, the implementation of the experiment was almost unmanageable.

During the past two growing seasons, a method has been developed that permits adequate testing of the combined effects

Researcher Michael Jeffords spraying a plot after defoliation was completed (Photo by Marcos Kogan).

of defoliation and weed competition. The work of researchers Charles Helm, Michael Jeffords, and Marcos Kogan used a common broadleaf weed — velvetleaf, *Abutilon theophrasti,* and the soybean looper, *Pseudophesia includens.* The test is established on a one-acre matrix of conventional soybean of a common commercial variety. They applied a grass herbicide and used hand weeding to eliminate other unwanted broadleaf weeds.

Velvetleaf seedlings were grown in the greenhouse and at crop emergence the plots were established with previously selected weed concentrations — four weeds per plot in 1981 and four and eight in 1982. Approximately two weeks prior to the date at which defoliation was to be effected, the 6 x 6 feet plots were covered with walk-in saran cages. Defoliation was produced by feeding of soybean looper larvae.

The soybean looper is well adapted to soybean but usually does not eat velvetleaf. Each plot's larval population resulted from eggs oviposited by 100 female moths released inside each cage. The progress of defoliation was carefully monitored until it approached the desired levels (60% in 1981, 30% and 60% in 1982). Random samples of 10 leaflets were taken from each cage and the actual defoliation level was measured with an electronic leaf-area meter. When defoliation reached the desired level, the cage was removed, and the larvae killed with a spray of methomyl. In 1981 it was determined the cage had no effect on yield so no control was necessary for the variable in 1982.

Synchronization of all operations is essential. The insect culture in the laboratory must be handled so that ovipositing moths in the correct quantities are available at the proper time.

This experimental procedure permits the performance of rather complex testing in a relatively small area and with a lower demand for labor. Defoliation is natural and has none of the drawbacks of simulated injury (hand-defoliation). A similar experimental design is now being considered involving superposition of a third class of pest — a leaf disease. Analysis of the 1982 experiment awaits yield data but the Survey scientists are confident, from the observations made so far, that the design is satisfactory and should provide a good first approximation for the establishment of economic injury levels of weed/defoliation interactions.

Biology of a Wild Bee

Honeybees and bumblebees are among the most familiar and conspicuous insects. The honeybee, well known as a producer of honey and beeswax and as an important pollinator of many crops, represents but a single species of insect, *Apis mellifera.* It is not native to this country, but was brought from Europe by the early settlers of North America. Bumblebees, large, hairy, usually black and yellow insects, represent a number of species in the genus *Bombus,* all of which are native to this country.

In addition to these, there is a much larger group of bees (in terms of number of species) known collectively as native, solitary, or wild bees. There are perhaps 20,000 species of wild bees in the world and about 350 of them can be found in Illinois. They are a diverse group both in appearance (some being less than a quarter inch long, others as large as bumblebees) and in behavior. Wild bees are important pollinators of many native shrubs and wildflowers as well as commercially valuable plants such as fruit trees and alfalfa, a fact that is often overlooked or little known. Because of their interesting behavior, wild bees have been the subject of considerable scientific research and the taxonomy of the superfamily Apoidea (taxonomic group that includes all bees) is one of the best known of any group of insects.

Cell of *Andrena erythrogaster* showing pollen mass with egg laid on top of it (Photo by David J. Voegtlin).

Graduate student Eugene Miliczky, under the direction of Survey entomologist Wallace E. LaBerge, has been studying various aspects of the biology of several species of native bees belonging to the genus *Andrena.* Of special interest are three species of *Andrena* that feed their young almost exclusively with pollen gathered from various species of willow trees. These three species, like many other species of wild bees, have an adult stage (the winged, reproductive stage) that is active for only a short time each year. The rest of the year is spent underground, in hollow twigs, and in similar locations (depending on the species) as an immature form or as a "resting" adult. Adults of the three willow bees can be found in the Champaign area from late April until the middle of June. At this time the adults have died off and will not be seen again until spring. Their young, however, have been well provided for.

Available information indicates all species of *Andrena* dig nests in the ground. *Andrena erythrogaster,* one of the willow bees, is no exception. Nests of this bee, sometimes called the red-bellied bee because of its bright red abdomen, were found in the woods at Lodge Park in Piatt County. Fifteen nests were located and studied during the spring of 1981 and a smaller number in 1982. Each nest was occupied by a single female bee that dug through the well packed dirt using her mandibles (one of her mouthparts) and legs. The resulting burrows descended nearly vertically into the ground for depths of 6-10 inches. Soil from the burrow was

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pushed to the surface by the bee and made a mound that resembled an ant hill around the entrance.

At various points along the main burrow the bee dug horizontal branches an inch or two in length. At the end of each branch a cavity or cell was made. The cells were oval in shape, about a half an inch long and a quarter inch in diameter. The walls of the cell were made very smooth by the female bee and she then applied a waterproof secretion to them. At this time the bee began to gather pollen and nectar.

Several loads of pollen and nectar were brought back to the nest and placed in the cell. They were then mixed together and shaped into a somewhat flattened sphere. An egg was laid on top of the pollen mass and the branch burrow leading to the cell was tightly packed with soil. The female bee had no further contact with the egg or the larva that hatched from it. She had, however, provided enough food for the complete development of a new bee. The larva that hatched from the egg consumed the entire pollen mass and then pupated. By early autumn the pupa gave rise to an adult bee which remained in the cell over the winter. This bee, representing a new generation, dug its way out of the soil the following spring when the willows were once again in bloom.

The hard-working female bees probably rear seven or eight offspring each in an average year. By the end of their lives their mouthparts have been worn down by digging, their wings are tattered, and much of their hair has worn off. Exhausted by constant work, they die and can be found frequently at the bottom of their nests. In contrast to the females, male bees make very poor fathers. Their primary concerns in life are finding and mating with one or more females and locating sources of nectar on which to feed. They take no part in digging the nest or providing for the young.

The nesting biology of willow bees is one phase of this research. Others concern the foraging behavior of the different species of willow bees, phenological relationships of the bees and the species of willows they visit, and the role of bees as pollinators of willows.

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NATURAL HISTORY SURVEY REPORTS

Records of North American Big Game

The Section of Wildlife Research of the Illinois Natural History Survey was host recently to a training session to certify official measurers for the Boone and Crockett Club. The session was jointly sponsored by the Illinois Department of Conservation and the Boone and Crockett Club. Glen Sanderson, head of the Wildlife Research Section at the Survey, has been the only official measurer in Illinois for the past 17 years.

Sixteen biologists, veterinarians, and wildlife managers attended the four-day training session. Two were from Illinois; three from Missouri; and one each from Iowa; Indiana; and Alberta, Canada.

The Boone and Crockett Club made its first formal recognition of outstanding big-game trophies in North America in the Club's 1932 records book. This first recognition involved only a few specimens and simple measurements such as length and spread of horns, antlers, or skulls. The records book of 1932 was followed in 1939 by a records book that included many chapters on a variety of subjects related to big game and hunting.

Engaged in measuring are (left to right) Forrest Loomis, Department of Conservation; Al Woolf, Southern Illinois University; Mike Cochran, Department of Conservation; and W. H. Nesbitt, Boone and Crockett Club.

The Club held its first "competition" for outstanding trophies in 1947. These trophies were ranked by a series of measurements that were refined in 1950 into the present scoring system for trophies. Since the 1947 "competition," there have been 17 Awards Programs, as they are now called. In recent years, the Awards Programs are held after the close of a three-year period of entry of trophies.

Trophies are measured by official "measurers" certified by the Boone and Crockett Club. Because Sanderson has been the only official measurer in Illinois, individuals with trophies to be measured often had to make a trip of several hundred miles in order to have a trophy measured. Although a variety of big game animals are measured — bears, cats, walrus, elk, deer, moose, caribou, pronghorn, bison, Rocky Mountain goat, muskox, and wild sheep — the species most often measured in Illinois is the white-tailed deer. Primarily because of increasing interest in "trophy" white-tailed deer in Illinois, for several years Sanderson has been encouraging the training of additional official measurers for Illinois. This interest was shared by Forrest D. Loomis, Forest Wildlife Supervisor, Illinois Department of Conservation.

The course was conducted by Harold Nesbitt, Secretary, Records of North American Big Game Committee, and his assistant Al Manville from the Club office in Alexandria, Virginia. Nesbitt took graduate training in wildlife management at the

Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale. The instructors brought several examples of the various types of big-game trophies and used them in the training sessions. Many local sportsmen, and other interested individuals, examined these trophies during the training session.

The name "Boone and Crockett" has long been associated with big game trophies in North America, and the record keeping program for native big game species is one of the Club's better known activities. However, this activity is only one of the many conservation activities of the Boone and Crockett Club. As part of these activities, the club regularly sponsors graduate-level wildlife research, primarily on big-game species. Recently the Club sponsored two workshops on the life history and management of the black bear and the wild sheep in North America. The results of these two workshops have been published in paperback books. Eight editions of *North American Big Game* have been published by the Club. These books are valuable handbooks for trophy hunters, wildlife managers, and students of big-game populations. The eighth edition, published in 1981, lists the trophies added during the 1977-1979 period to those listed previously and brings the total to nearly 7,000 individual trophies in 31 categories. Entries for the 1980-1982 awards must be postmarked no later than December 31, 1982.

Individuals who wish information on the Boone and Crockett programs and awards should write to Boone and Crockett Club, 205 South Patrick Street, Alexandria, Virginia 22314. Residents in Illinois interested in having trophies measured should contact Forrest D. Loomis, Illinois Department of Conservation, 125 North First Street, Monmouth, Illinois 61462.

Aquatic Insects and Oligochaetes of North and South Carolina

A recent publication, *Aquatic Insects and Oligochaetes of North and South Carolina*, edited by Allison R. Brigham, Warren U. Brigham, and Arnold Gnilka, is the first comprehensive account of these elements of southeastern fauna. This work should serve not only as an introduction for the beginner, a working manual for the aquatic biologist, and a handy reference for the specialist, but also should provide a stimulus to further investigation into a fascinating area of biology.

It treats approximately 2,500 species in 837 pages, and has over 2,000 illustrations plus a systematic index. The book is an outgrowth of the long tradition of aquatic research and faunal studies established at the Illinois Natural History Survey over the last 125 years. The Survey's scientific collections provided a rich source of specimens for the study, and the authors were able to use many of the excellent illustrations of insects which have appeared in past Survey publications on the Illinois fauna.

In late 1973, Duke Power Company asked Allison R. Brigham and Warren U. Brigham of the Illinois Natural History Survey, and Arnold Gnilka of Duke Power Company, to put together a team of biologists in order to conduct a faunal study and prepare an identification manual for the freshwater benthic macroinvertebrates in their service area (the piedmont region of North and South Carolina). In addition to A. R. Brigham and W. U. Brigham, M. W. Sanderson, J. D. Unzicker and D. W. Webb of the Survey took part in the project. Other authors included specialists from the University of Michigan, University of California, Eastern Illinois University, Clemson University, Kansas State Biological Survey, and the states of North Carolina and South Carolina.

Originally the manual was conceived as an in-house document to be used by Duke Company's staff to provide accuracy of identification of benthic macroinvertebrates in their biotic surveys and long-term monitoring programs in the Carolinas. As the project developed, the scope of the study was expanded to include the fauna of all three physiographic regions (mountain, piedmont, and coastal plain) of North and South Carolina. In addition, the authors were asked to review the North American literature on the biology of these organisms, and synthesize it into a single, comprehensive work.

Each chapter of the book covers an order of insects plus the aquatic worms or *Oligochaeta*.

Biological Control of the Musk Thistle in Illinois

About 120 years ago, the musk thistle was introduced accidently into Pennsylvania from Europe. Without its natural enemies to suppress its reproduction, it spread quickly to inhabit roadsides, pastures, and waste areas throughout much of the United States. In Illinois, the weed grows well particularly in strip mine areas converted to pastures.

In an attempt to control this weed biologically, Illinois Department of Agriculture personnel, in cooperation with the Illinois Agricultural Experiment Station, released a weevil native to Europe, *Rhinocyllus conicus,* at six locations in Illinois during 1979 and at three additional locations during 1980. After the initial establishment of the weevil (see *Natural History Survey Reports,* September 1980, No. 199), its populations and their effect on musk thistles have been monitored through a joint effort of the Illinois Department of Agriculture and the Illinois Natural History Survey.

The weevils overwinter as adults and generally are seen first on thistles in early May. Adult feeding at this time causes small brown spots on the leaves; however, this has little effect on the plant. After feeding and mating, the females lay eggs on the bracts of developing flower heads. The larvae hatch from the eggs and bore into the base of the flower or receptacle.

The primary damage to thistles is caused by the larvae. Larval feeding in the receptacle prevents the development of some or all of the seed within the head. To prevent the development of all seeds within a head about 20 larvae must inhabit a seed head. At a certain stage of development the larvae stop feeding and pupate within a hard brown chamber in the receptacle. In a few days the final change from pupa to adult takes place. By the end of July, the new adults leave the heads to find overwintering sites, and become dormant until the next spring.

Larvae of the musk thistle weevil, *Rhinocyllus conicus,* feeding within the receptacle of a musk thistle seed head (Photo by William Lamp).

Weevil populations have been increasing slowly and destroying more seeds each year since the initial releases in Illinois. At a release site in Fulton County this year, Survey Research Associate William Lamp found nearly 90 percent of the terminal seed heads contained weevils and that the weevils had spread to thistles about a half mile away. Last year, 62 percent of the terminal heads contained weevils. A similar pattern of population buildup and dispersal during the first five to seven years is common among release sites in other states, and is usually followed by a rapid increase of weevil populations and a decrease in thistle seed production.

The weevil generally attacks the first flower heads developing on a thistle and allows heads developing later to produce their full complement of seeds. At the Fulton County site, up to 17 larvae inhabited the terminal heads, but the later-blooming lateral and axillary heads were usually free of weevil attack. The larval stage of another insect species, *Homoeosoma ellectellum,* the sunflower moth, was often observed feeding on thistle seeds. The adults of this insect commonly attack the native sunflowers and usually cause little damage to the musk thistle.

The weevil is not expected to eradicate the musk thistle, its only host plant in Illinois, but rather to reduce its population to a low level. If further reduction of thistles becomes necessary, additional biological control agents may be released. U.S. Department of Agriculture researchers are currently investigating other insect

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species that may be released in the USA. As with all biological weed control agents, these insects are tested to make certain they will not become pests on crops and other beneficial plants.

The impact of the weevil on musk thistle populations up to this time is difficult to assess. Although original stands in which releases were made have almost disappeared, new stands have developed in nearby areas. This reflects the patchy distribution of the thistle, with the location of stands shifting between generations. Once the weevil severely reduces seed production, the establishment of new thistle stands and their subsequent population growth are expected to decrease.

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Injection Wounds and Tree Growth

Certain nutritional, pathological, or entomological maladies of trees can be remedied by implantation or injection of chemicals into the trunks of trees. Examples of two treatments that may be recommended by Survey pathologists are correction of lime-induced iron chlorosis of pin oaks with implants and treatment of incipient stages of Dutch elm disease in specimen elm trees with injection procedures. Trunk wounds are required prior to treatment and wound size is a major factor in determining the method of treatment.

Previous experiments have determined that wound closure is correlated with wound width and tree growth. A recently completed study by Dan Neeley, Survey plant pathologist, was designed to determine (1) if intentional wounding over a period of years would result in reduction of tree growth, and (2) the correlation between tree growth and wound size.

Trees of five species at two locations, the Survey arboretum south of Urbana and the Morton Arboretum west of Chicago, were treated for four years (1977-1980). Wounds were of two types: circular and pointed elliptical. Four whorls of circular wounds were cut into the trunks at three-inch intervals: the whorls were one foot apart. The circular wounds were 3/8, 1/2, and 11/16 inches in diameter. One whorl of elliptical wounds two inches tall and one inch wide was cut into the trunks at three-inch intervals each year. Trunk diameter increases and wound closure were measured annually.

The wounded trees grew just as rapidly as the untreated trees. It would appear that wounding of trees for injection or implantation of a chemical will not measurably slow tree growth if the chemical itself is not toxic to the tree.

Although there was a difference among tree species, the 3/8-inch wounds closed in one season with .10 inch, 1/2-inch wounds with .15 inch, and the 11/16-inch wounds with .23 inch of radial growth of the tree trunk. The larger the wound, the lower the

Following drilling holes in the trunk, the tree is pressure injected with chemicals that aid in remedy of some vascular diseases (Photo by Eugene Himelick).

number of wounds that completely closed the first season. In these test plots, essentially all of the 3/8-inch wounds closed, 80 percent of the 1/2-inch wounds, and 50 percent of the 11/16-inch wounds closed in one year. This confirms the suggestion that wounds should be as small as practical when using implant or injection techniques.

Biological Collections

Collections of biological materials contain enormous amounts of information. This information is contained in the specimens themselves as well as in the recorded information taken at the time the specimens were collected in the field. The amount of information with the collections increases with the passage of time. This is because the collections record events in history and these data can be used as a comparison between the past and the present.

The most obvious use of collections is for the identification of organisms. For example, if an unknown specimen is sent to the Illinois Natural History Survey for identification, the scientist frequently goes to the collection to compare this specimen with previously collected organisms. Without the collections, it would be more difficult, often impossible, to identify many plants or animals which are collected today. These identifications are frequently of economic importance, perhaps as pest species.

Collections also represent a record of the changing distributions of species. By going to the records, it is possible to decide whether man's activities have had an adverse effect on animal and plant populations. For example, a citizens' group might maintain that a power plant has not decreased the number of fishes in a given stream. However, by reviewing collection records, it might be possible to show that the stream previously contained much larger fish populations and therefore the power plant could be made to assume the responsibility for the decreased number of fishes.

Two other examples indicate ways in which the collections are frequently of great economic value. In 1975, an unknown insect was found infesting soybean fields in southern Illinois. The farmers immediately began spraying because they thought this insect carried a bacterial disease which kills soybeans, the tobacco ring spot. Scientists from the Illinois Natural History Survey collected the unknown insect and, using the collections, identified it as a thrips, *Sericothrips variabilis*. The scientists also used the international literature file at the Survey and found an Egyptian paper which indicated that this particular thrips did not carry the bacterial disease. Subsequently, in the laboratory, the scientists also confirmed that the thrips did not carry the bacterium. Further, field investigations showed that fields which had been sprayed actually demonstrated decreased soybean growth. Within five days, scientists from the Survey were on local television advising the farmers that the thrips did not carry the disease and, furthermore, that spraying should not occur.

A second example involved edible plants, i.e., turnips and horseradish. Many of these plants in southwestern Illinois showed deformities during the growing season of 1978. The USDA decided that these Illinois crops should be quarantined and not sold. Scientists from the Survey again used the collections and within two weeks had identified the insect causing the damage, the imported crucifer weevil. The investigation showed that the quarantine was unnecessary, and eventually a crop protection program was developed. Once again, the collections resulted in an identification which was of considerable economic value.

Adding to the collections is a continuous process. For example, on June 18, 1982, one of the Survey scientists collected a sunflower beetle in East Moline. This was the first recorded occurrence of this insect east of the Mississippi. Unfortunately, this insect is a major pest of commercial sunflowers in Kansas. Again, the collections provided not only the identity of the organisms, but also established a permanent record of its occurrence in Illinois.

The Illinois Natural History Survey is the official depository of animal collections within the State of Illinois. There are

Researcher Don Webb checks a specimen drawer in the Survey insect collection (Photo by Les Woodrum).

almost 5,000,000 specimens in the insect collection. It is the fifth largest in North America, includes the largest collections in the United States of several groups of insects, and contains over 3,000 type specimens. Type specimens are the actual specimens from which the original species description was written.

Also among the Survey collections are 200,000 specimens of soybean arthropods, which represent the International Reference Collection; 75,000 mollusks, the 12th largest collection in North America; 200,000 other invertebrates; 400,000 fishes, the 16th largest in North America and the largest collection of Mississippi River fishes in existence; and 11,000 amphibians and reptiles.

These collections are maintained in various ways. Insects and arthropods are stored usually as dry specimens on pins in special containers. On the other hand, fishes and some invertebrates are stored in alcohol.

Computers Aid in Fight

Economic entomologists conducting research on insect pests of alfalfa and other forage crops installed a minicomputer and word processor in their laboratory recently. This system allows for storage and retrieval of large amounts of data collected in the field and laboratory, historical type data, and references to published scientific research by colleagues throughout the world. Retrieval of information can be easily and quickly accomplished. Because of the system's communications capabilities, it is possible for researchers to use all the functions of the University's massive computer system. This, therefore, allows for extensive computer analysis of data. Researchers can also communicate with other researchers throughout the United States.

This type of communication is extremely valuable to Survey and Agricultural Experiment Station entomologists, W. O. Lamp and E. J. Armbrust, who are involved in a multi-state research project to develop comprehensive, unified, economically and environmentally sound pest management systems for alfalfa. The objective of these systems is to minimize losses to pests while optimizing the productive longevity of alfalfa. Entomologists, weed scientists, and plant pathologists in Illinois, Kentucky, California, Wisconsin, and New York are working together and are being funded in part by the U.S. Department of Agriculture to accomplish these aims. The use of minicomputers and word processors has greatly assisted with the availability of data and its analysis by all researchers in this project.

Lamp and Armbrust have been working extensively with Southern Illinois University weed scientist, George Kapusta, to determine an interaction of the potato leafhopper insect pest and weed pests found in alfalfa. Weekly samples of insects,

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weeds, and crop growth and yield for two years in alfalfa fields has produced large quantities of data that have been stored and analyzed through this minicomputer.

The potato leafhopper is a major insect pest in alfalfa and studies have shown that its presence may be reduced by the presence of weeds. The number of leafhoppers averaged 31 percent less in alfalfa where grass weeds were not controlled. Although the weeds do compete with the alfalfa, only the quality of the yield and not the quantity is reduced in this weedy alfalfa.

Several explanations for the effect of weeds on insects are presently being pursued. For example, the grass weeds are hosts for many other leafhopper and planthopper species. These noneconomic insects may compete with potato leafhoppers and reduce their populations.

Additional ways that weeds may influence insect pests are by serving as alternate hosts, confusing host-locating mechanisms, or altering host plant suitability. Once the cause of the observed interaction is known, techniques will be developed to manage the potato leafhopper using information on weed populations in alfalfa. If economic levels are lowered by such interactions, then fewer herbicides will be required for controlling weeds. In addition, fewer insecticides will be required for controlling leafhopper populations in weedy alfalfa. In general, the studies of weed-insect interactions have resulted in the integration of control strategies for pests of different disciplines, thus making the alfalfa production system more efficient.

When these control strategies are introduced at the grower level, pest population information pertaining to the various pests can be implemented and the proper control strategies can be disseminated through the use of minicomputers. Communication and data storage and analysis at this level of sophistication will make alfalfa production more efficient with less harm to the environment through the proper use of pesticides. A production system of this type could result in an increase in the longevity of the alfalfa crop.

Because alfalfa is a perennial legume with outstanding nitrogen-fixing capabilities, it is of major importance in energy and soil conservation. Crop establishment and long-term maintenance costs in terms of energy and erosion can be greatly reduced through utilization of alfalfa. The development of efficient strategies for pest population regulation and control can further reduce the amount of energy required for production. For example, if the longevity of alfalfa was extended for only one year, the increased production and energy savings would exceed $325,000,000 on a national scale.

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Scientists Unite to Provide Food

The problem of providing food and nutrition for escalating populations in developing countries is enormous, with more than one billion people (about ¼ of the world's population) known to be underfed or malnourished. These numbers and proportions may grow even faster than the world population, which is projected to exceed six billion by the year 2000.

A major attack on this problem was launched at a recent international conference in Manila attended by Survey Aquatic Biologist D. Homer Buck. He participated in the workshop on Aquaculture and Integrated Farming. Buck's working group numbered 13, including seven from Asia, two from Africa, one each from Sweden and Australia, and Ed Lincoln of the University of Florida, who conducts research in the intensive production of microalgae in organically enriched systems.

Proceedings and reports emanating from the conference and workshops will be available for reference at the Kinmundy field station.

The meeting was called CHEMRAWN II (Chemical Research Applied to World Needs), with the more formal title of International Conference on Chemistry and World Food Supplies: The New Frontiers. Principal sponsors were the International Union of Pure and Applied Chemistry and the International Rice Research Institute.

The specified objectives of the conference were (1) to identify and put into perspective those areas of research and development having the potential to significantly increase food production and improve food storage and processing; (2) to strengthen scientific research in developing nations, particularly in those fields which require professional competence and initiative without excessive capital and human resources; and (3) to accelerate implementation of research priorities and objectives by fostering cooperation among governments, industries, and universities.

The formal scientific papers were presented by a selection of distinguished international scholars, including five Nobel Laureates. Papers were presented in seven separate sessions: Soil and Crop Management for Efficient Use of Water and Nutrients, Integrated Approaches to Pest Management, The Role of Chemistry and Biochemistry in Improving Animal Production Systems, Contributions of Chemistry and Biochemistry to Developing New and Improved Food Sources, Chemistry and Biochemistry in the Processing and Storage of Food, Chemistry in the Assessment and Control of the Food Supply, and The Forward Edge.

As anticipated, the most exciting and imaginative subjects were discussed in the last session, The Forward Edge. Subjects addressed here included potentials and prospects in genetic engineering, wide crosses in plants, new strategies and methods for selection and utilization of germplasm, the role of growth regulators and hormones in enhancing food production, the potentials for increasing rates of nitrogen fixation, and for improving the efficiency of photosynthesis.

The second phase of activities, the post-conference workshops, were convened in the impressive facilities of the International Rice Research Institute adjoining the campus of the University of Philippines at Los Banos. The activities at Los Banos were

funded by the US Agency for International Development, and were organized by the US National Academy of Sciences, more specifically by the Board on Science and Technology for International Development (BOSTID), which was responsible for selecting the participants in four separate workshops:

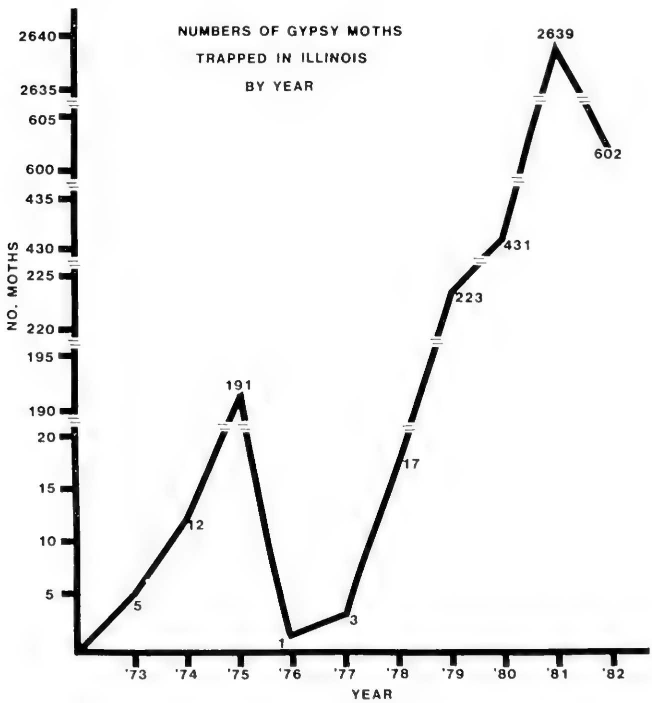
(1) Soil Fertility and Plant Nutrition
(2) Plant Growth Regulators and Plant-pest Relationship
(3) Food Science and Technology
(4) Aquaculture and Integrated Farming Systems.

The responsibilities of the workshop participants were to combine the information presented at the conference with their own knowledge and observations in identifying those research areas having the highest potential for improving food supplies in developing countries, and which should receive highest priority for funding. Where possible and appropriate, cooperative studies will be conducted jointly in a developed and a developing country.

The Gypsy Moth in Illinois

The gypsy moth, a tremendously destructive tree pest, has now reached Illinois from the northeastern United States. The moth is often unintentionally transported to Illinois by families moving to Illinois from infested areas in the east. The Illinois Department of Agriculture is responsible for monitoring the spread of this insect by the use of gypsy moth sex pheromone traps for the detection of adult male moths. Illinois Department of Agriculture personnel have traps in all counties of Illinois.

The Illinois Natural History Survey team of scientists and technicians, in cooperation with the Illinois Department of Agriculture, is using trapping data to assess the future probability of outbreaks of the gypsy moth. A high male moth trap catch in a particular area indicates that larvae of the gypsy moth have been feeding in that area for one or more years. Infested areas are scouted extensively for gypsy moth egg masses during the autumn and winter months by Illinois Department of Agriculture's staff and when egg masses are found they are carefully collected and either destroyed or transported to the Natural History Survey's quarantine laboratory at Champaign. There the eggs are examined for viability, parasites, and disease organisms. Only two percent of the eggs in egg masses collected in March 1982



Graph shows rapid increase in number of gypsy moths in Illinois; drop in summer of 1982 was caused by severe winter weather of 1981-1982.

were viable, and the high egg mortality was attributed to the adverse winter climate of 1981-1982.

The first detection of gypsy moths in Illinois occurred in 1973 when two moths were captured in Cook County and one each in Rock Island, Sangamon, and Will counties. The records on moth catches in Illinois vary considerably from year to year due to control programs, climatic conditions, number of traps used by the State Department of Agriculture and the status of the gypsy moth population in the northeastern portion of the United States. Severe gypsy moth outbreaks in eastern states increase the chances of gypsy moth egg masses and pupae being unintentionally transported into Illinois. Cooperative studies with the Illinois Department of Agriculture will continue, since their help is vital to our understanding of the gypsy moth problem in the state.

Possible Effects of Reduced Tillage In Corn on a Black Cutworm Parasitoid

The black cutworm, *Agrotis ipsilon* Hufnagel, is well known to Survey entomologists as a major pest of seedling corn in the Midwest. Adult moths migrate into Illinois in the early spring, and lay their eggs on weeds and crop residues within or bordering fields before corn is planted. Young larvae feed on these plants till corn seedlings emerge; they will then start feeding on corn leaves, particularly if planting and cultivation have removed all other vegetation. Older cutworms cut corn seedlings at the base, and in sufficient numbers can cause serious economic damage.

Reduced tillage in corn is currently being encouraged to conserve energy and decrease soil erosion. These positive effects must be weighed against trade-offs such as increased insect and weed problems. Certain insects, such as the black cutworm, are expected to cause economic damage more frequently in reduced-tillage corn because of increased crop residues and weediness in fields before planting. Survey researcher Mike Foster suggests that it is important to determine the effects of reduced tillage on natural enemies of corn pests as well as the pests themselves. Predators and parasitoids do not control corn pests, but are important because their activity decreases the frequency and severity of damage. As a graduate student working with Bill Ruesink, Survey entomologist, Foster has been looking at the effects of weeds common in reduced-tillage fields on a major black cutworm parasitoid, *Meteorus leviventris* Wesmael.

This parasitic braconid wasp attacks cutworms just old enough to cut corn seedlings, and the development of its young inside the host kills cutworms prematurely. Consequently, parasitized cutworms cut fewer corn seedlings. Foster learned from laboratory observations that *Meteorus* females live longer, attack more cutworm hosts, and produce more offspring if they are provided with an energy source such as honey water. In addition, many species of parasitic wasps and flies are known to benefit from floral nectar both in natural habitats and in various crops. Armed with this information, Foster hypothesized that some of the flowering weeds found in reduced-tillage corn provide nectar which benefits *Meteorus* and increases its effectiveness as a black cutworm parasitoid.

In the fall of 1981, laboratory experiments were conducted to determine the effects of five flowering weeds on adult female *Meteorus*. Three of these weeds, chickweed, mustard, and shepherd's purse, are common and flowering in reduced-tillage fields before planting. The other two species, wild parsnip and lady's thumb smartweed, are common and flowering in field borders or nearby uncultivated areas soon after planting. These experiments demonstrated increased longevity, repro-

Actual size of *Meteorus leviventris* female above is 3½ millimeters (Photo by Les Woodrum, Survey Photographer).

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duction, and more hosts attacked by wasps provided with these flowers, in comparison to starved female *Meteorus*.

In the spring of 1982, a field experiment was set up to determine if flowering weeds would result in increased parasitism and decreased cutting damage under seminatural conditions. One-meter-square plots of seedling corn enclosed in field cages were subjected to three treatments: 20 cutworms, cutworms and 10 female wasps, or cutworms, wasps, and flowering weeds accessible only to the wasps. The results suggest increased parasitism and decreased cutting damage in the presence of flowering weeds.

A greenhouse experiment was conducted in the fall of 1982 to determine how increased wasp lifespan, an effect on individuals, translates into increased parasitism, an effect operating at the population level. Two variables were manipulated: the presence of flowering chickweed and the initial ratio of wasps to cutworms. Foster hypothesized that nectar, by increasing wasp lifespan, would increase the average wasp-to-cutworm ratio over several days and consequently result in greater parasitism. Flowers did indeed increase the average wasp-to-cutworm ratio over several days, but this resulted in greater parasitism only if the initial wasp-to-cutworm ratio was low. These results imply that an adequate nectar supply will have the greatest impact on field rates of parasitism when spring populations of *Meteorus* are low.

The experiments described demonstrate that *Meteorus* benefits from flowering weeds common in reduced-tillage corn. Two other major parasitoids of the black cutworm are *Bonnetia comta,* a tachinid fly, and *Microplitis* (two species), a braconid wasp. Both insects are known to benefit from a sugar source and these flowering weeds may also be beneficial to them.

Because reduced tillage affects both cutworms and their natural enemies, its effect on the risk of cutworm damage is likely to be quite complex. For example, if natural enemies are not considered at all, one would predict an increased risk of cutworm damage with moderate levels of weediness before planting. However, if there were sufficiently high levels of *Meteorus* in the early spring and they were benefited sufficiently by a nectar supply, this might offset the increased levels of cutworms. Foster is currently developing a computer model to determine by simulation the effects of weed-*Meteorus* and weed-cutworm interactions on parasitism and cutting damage. This model will allow researchers to distinguish situations in which preplant weediness can be tolerated from those in which weediness will increase the risk of cutworm damage.

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Transmitters Designed for Condor

A tiny, solar transmitter designed and made by W. W. Cochran, Jr., associate wildlife specialist at the Survey, has enabled scientists to tag and track a California condor by plane during the past few weeks. Cochran is in California working on an automatic receiver that will eliminate the need for cars and planes in tracking the bird.

The first free-flying California condor was captured last fall near Ventura. Dr. Noel Snyder, condor research biologist for the U.S. Fish and Wildlife Service, fired the cannon-net over the condor while it was feeding on a calf carcass. It resisted strenuously, biting the hands of its captors, but displayed no signs of stress during the initial examination.

The bird was held at the San Diego Zoo while blood samples were taken and analyzed to determine its sex. It proved to be a 22-pound male. The condor was fitted with two solar-powered transmitters and then released. It has been followed by an airplane most of the time since the release.

Dr. Noel Snyder, U.S. Fish and Wildlife Service, attaches Cochran transmitter to condor as his assistants hold bird (Photo by Helen Snyder, U.S. Fish and Wildlife Service).

The California Fish and Game Commission authorized the trapping of immature condors late in 1982. However, only two birds can be taken into captivity under the permit for a year. Trapping has now been resumed to capture a female of the species.

Begun late in 1979, the purpose of the program is to identify factors causing the continued decline of the wild California condor population, and at the same time, to breed the birds in captivity for eventual release in the wild.

The California condor research project is a cooperative effort among the Fish and Wildlife Service, the National Audubon Society, the California Fish and Game Commission, the Forest Service, the Bureau of Land Management, and the Illinois Natural History Survey.

For at least 20 years, Cochran has been designing and making various kinds of transmitters and receivers for tracking all kinds of wildlife including small birds, ducks, geese, rabbits, deer, and even fish.

Wildlife specialists agree that more meaningful interpretations of the lives of animals will result from finding out what an animal is doing at a particular place at a particular time, and how its pattern of activities fits into its year-round needs for successful survival and reproduction.

The Aster Leafhopper: A New Vector of *Spiroplasma citri*

In 1981 University of Illinois plant pathologists and Survey entomologists reported the discovery that *Spiroplasma citri* is the causal agent of brittle root disease of horseradish in Illinois. *S. citri*, well known for its association with a severe disease of citrus in the southwestern United States, is

a small, helical, bacterialike organism found in the phloem of diseased plants and transmitted by leafhopper vectors. One of these vectors, the beet leafhopper (*Circulifer tenellus*), was shown to transmit the spiroplasma from brittle root-diseased horseradish to healthy horseradish plants in laboratory tests.

While the beet leafhopper was collected in horseradish fields during several brittle root epidemics, it was not found during the 1975 outbreak despite intensive sampling of horseradish fields. This discrepancy led Survey entomologists Karen O'Hayer, Gerald Schultz, and Catherine Eastman and University plant pathologists Jacqueline Fletcher and Robert Goodman to investigate other leafhopper species as possible vectors of *S. citri* in Illinois. The aster leafhopper, *Macrosteles fascifrons,* was of special interest because it is already known as a major vector of several other plant pathogenic organisms and because it is collected routinely in Illinois horseradish fields, sometimes in large numbers.

An understanding of the type of pathogen-vector relationship involved was essential in determining the best means of testing the aster leafhopper as a potential vector of *S. citri.* This spiroplasma is one of several pathogens which are transmitted in a circulative-propagative manner. After being taken up by the insect during feeding, the pathogen must penetrate the gut wall and enter the circulatory system. From there it moves through the insect's body,

Aster plant on left was exposed to infected leafhoppers and shows stunting and chlorosis typical of *S. citri* infection. Aster plant in center was exposed to control leafhoppers, and the aster plant on the right was not exposed to leafhoppers (Photo by Les Woodrum, Survey photographer).

infecting and multiplying in various tissues, including the salivary glands. This whole process may take several days or weeks. The pathogen then can be introduced, along with the saliva, into the phloem of a host plant during feeding.

The first step in evaluating the aster leafhopper as a potential vector of *S. citri* was to determine if this insect could transmit the pathogen after being injected with a suspension of cultured spiroplasmas. The microinjection technique involves the introduction of a large quantity of the pathogen directly into the leafhopper's circulatory system, thereby increasing the chance of subsequent transmission. Aster leafhopper adults were injected with a horseradish isolate of *S. citri* and were caged on barley plants (a preferred host) for 14 days to allow time for the pathogen to circulate and multiply within the leafhoppers. Then the leafhoppers were confined on aster and horseradish test plants for 7-day feeding periods. In the combined results of two experiments, the leafhoppers transmitted *S. citri* to 27 of 41 aster (66 percent) and 11 of 46 horseradish plants (24 percent).

The success of the microinjection experiments indicated that *S. citri* could multiply in the aster leafhopper and could be introduced into plants during feeding. A true test of an insect's potential as a vector, however, is whether or not it can acquire enough of the pathogen naturally by feeding on infected plants to permit subsequent transmission of the organism to healthy plants. Sometimes the digestive tract of an insect species acts as a barrier, preventing passage of a pathogen into the blood. In separate tests aster leafhoppers were confined on *S. citri*-infected plants (aster, turnip, or bassicaceous weed yellow rocket) for 7-14 days. After another 7-14 days on barley, leafhoppers were caged on test plants (aster, horseradish, or turnip) for 3-7-day feeding periods. In combined results from four experiments, leafhoppers transmitted *S. citri* to 9 of 128 aster (7 percent), 1 of 69 horseradish (1 percent), and 3 of 54 turnip (6 percent) plants.

Infected aster and turnip plants developed chlorosis and stunting of young leaves and reduced overall plant growth. Infected horseradish plants were stunted and chlor-

otic with reduced secondary root growth and phloem discoloration characteristic of brittle root disease. All control plants exposed to leafhoppers fed previously only on healthy plants remained free of symptoms. To confirm these results, attempts were made to isolate spiroplasmas from plant tissues; spiroplasmas were present only in plants with the described symptoms.

The discovery that the aster leafhopper can transmit *S. citri* after acquiring it by feeding on diseased plants strongly suggests that this species may be a natural vector of the spiroplasma and, thus, may be involved in the epidemiology of brittle root disease. The transmission frequencies in these tests were low, but this does not lessen the potential importance of the aster leafhopper as a vector of *S. citri*. Inefficient transmission could be compensated for by the large populations of this insect which often occur in the Midwest. The plant host ranges of both *S. citri* and the aster leafhopper include species in the families Asteraceae, Violaceae, Fabaceae, Brassicaceae, Rosaceaem, Ranunculaceae, Malvaceae, Caryophyllaceae, and Liliaceae. Therefore, the aster leafhopper may be involved in the spread of *S. citri* to other susceptible plants in addition to horseradish. The potential importance of this insect as a vector of *S. citri* is enhanced further by the fact that of the four known vectors of spiroplasma, the aster leafhopper has the most extensive geographical range, which includes Mexico, the continental United States, and most of Canada.

Aquaculture May Become New Illinois Resource

Because Illinois and nine other states produce about 75 percent of the country's waste products, Stephen Waite, aquatic biologist at the Survey, believes that this waste may turn out to be one of the state's most priceless resources.

Waite, who hopes to initiate an aquaculture program in Illinois, says even though the state is well known for its land-based agriculture, it has no large scale aquaculture at present. Aquaculture is the cultivation of aquatic plants and animals for human consumption. With populations increasing and good farmland

Swine are confined to cages over water at Kinmundy where aquaculture project was begun in 1975 (Photo by Les Woodrum, Survey photographer).

reaching its maximum productivity, more people are exploring ways to use aquaculture to meet the rising demand for food.

D. Homer Buck, another Survey researcher, has been working since 1975 on small-scale aquaculture systems using swine manure to culture fish. Swine, fed commercial chow, produce a great deal of manure. The manure is washed into a pond set below the hog pens where it serves as food for those lower in the food chain, specifically plankton and algae. These microscopic organisms in turn serve as food for fish such as carp and freshwater shrimp. One of the problems scientists had to work out was how much manure should be added to the system. Manure releases ammonia which is quickly utilized by algae. The algae bloom, then die. The decomposition process uses large amounts of oxygen, so much so that the fish can suffocate.

Waite has spent the last year looking for ways to overcome the problem of excess ammonia in the systems. He found what he was looking for in the Chinese water chestnut because it is an aquatic plant that requires its nitrogen in the form of ammonia. Water chestnuts are a popular food for human consumption and can also provide food for fish. The production of aquatic plants that serve this double function can be extremely valuable with regard to the overall economics of the system.

Waite suggests that commercial-sized systems be set up to produce crops year-round for the commercial market. The Survey is

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planning to design and build several units to demonstrate that aquaculture is economically feasible from a commercial standpoint in Illinois.

Waite says that farmland is so valuable in Illinois that good lands should not be converted to ponds, but lands can be found that are less productive. Because of the relatively short growing season outdoors, indoor systems under covered greenhouses could be used. Solar greenhouses and other specifically designed buildings could be used so that something could be planted and something harvested every month.

Indoor systems would have many advantages. It would be easier to eliminate mortality due to predators, to prevent and control disease vectors, and avoid contamination from industrial and agricultural toxicants.

Land, water, and other resources such as waste heat could be used more efficiently providing greater production per unit space and flexibility for siting near sources of recyclable waste.

According to Waite, the net benefit of these advantages would be maximum year-round production on a highly predictable basis — a big point to commercial markets — on a scale that justifies the operation of the systems.

New Publications List Is Being Processed

A much larger, more comprehensive Publications List is being edited and placed on the word-processor for easier future updating. The new material and method has made the production more time consuming. The new Publications List will be available in early summer. Requests are being held on file and will be filled when the publication becomes available.

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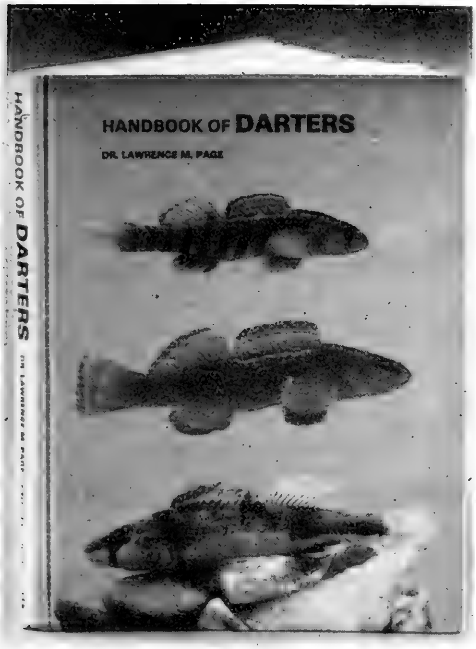

Book on darters was written by Survey researcher L. M. Page (Photo by Les Woodrum, Survey photographer).

Handbook of Darters Published

About 150 (20 percent) of the 800 species of freshwater fishes in North America north of Mexico are darters, small relatives of the walleye, sauger, and yellow perch. One species, the snail darter, is well known because of the recent highly publicized conflict between retention of its habitat in eastern Tennessee and completion of Tellico Dam. Other species are unknown generally to most persons, but are among our most colorful and interesting fishes. David Starr Jordan, a famous ichthyologist, referred to darters as "the most fascinating, vivacious, and individual of all river fishes."

A just-published book, *Handbook of Darters,* authored by Survey scientist L. M. Page, is now available from T.F.H. Publications, Inc., Neptune City, NJ 07753. Page discusses the identity, relationships, distribution, and natural history of the 129 named species and comments on most of the recognized but as yet unnamed species. Included in the book are 308 color photos, 89 distribution maps, and summary chapters on the ecology, evolution, and zoogeography of darters.

Darters are found in the Mississippi River, Great Lakes, Hudson Bay, Atlantic Slope, and Gulf of Mexico drainages, and one species lives in a Pacific drainage of Mexico. Most (87) species occupy the Mississippi River system. The largest geographic range is that of the logperch which ranges from Hudson Bay to the Gulf of Mexico and from Saskatchewan to eastern Quebec. The smallest range is that of the Maryland darter, which is confined to one riffle in Maryland.

Most darters reach a maximum length of less than 100 mm (4 inches). At a maximum recorded length of almost 200 mm (8 inches), the freckled darter, an inhabitant of Gulf slope drainages, is the giant among the group. The smallest, at 45 mm (1¾ inches), is the fountain darter, a species occurring in only one spring and its effluent in southern Texas.

Most species feed on microcrustaceans (copepods, ostracods, and cladocerans) as young and on immature aquatic insects as adults. A few specialize on snails and scuds (amphipods). Most spawn in spring, although at southern latitudes some may spawn for extended periods, and species occupying constant-temperature springs

may spawn the year round. Maximum life spans vary from 1½ to 4½ years, with large species living longer than small species.

Darters have reached their high level of diversity by occupying a wide variety of habitats. Many species are restricted to major physiographic regions; as examples, the swamp darter is found almost solely on the Coastal Plain, and the longhead darter is restricted to the Appalachian highlands. Other major determinants of distribution are habitat characteristics which may or may not correspond to physiographic boundaries, and competition with closely related species. The stringent requirements of many species make them vulnerable to extirpation, but also make them excellent indicators of the environmental health of streams and lakes. Most species occupy flowing habitats of streams and are unable to live in artificial impoundments. Many populations have been eliminated because of excessive deposition of silt on their former feeding and spawning grounds. Illinois historically had 27 species of darters; now it has only 23 species, several of which are rapidly becoming less common.

Publication of the *Handbook of Darters* follows over 150 years of research (the first species was described in 1818). Page has been studying darters since 1967. A substantial portion of recent research, especially life-history and systematic studies has been done at the Survey. Much remains to be studied, and the *Handbook* serves to elucidate needed areas of research as much as it summarizes existing information.

Small Pathogens of Small Animals

The Collembola, or springtails, are a group of minute animals that occur in damp soil, leaf litter, under bark, in decaying logs, in fungi, and on the surface of some freshwater pools. There are over 2,000 species of Collembola worldwide. They are quite common and often occur in great numbers, but because Collembola are so small, usually less than 4 mm long, they usually go unnoticed. This is unfortunate for persons having an interest in biology because Collembola have many fascinating characteristics.

Especially interesting is the structure that gives Collembola the name "springtails." This is a small forked structure on the ventral side of the fourth abdominal segment. At rest this structure is folded forward under the abdomen and held in place by a clasplike structure on the third abdominal segment. When the clasp releases the forked structure, it moves posteriorly with force, pushes the Collembola off its perch and propels it forward. A Collembola only 5 mm in length can jump 80-90 mm. Some species of Collembola may occasionally cause damage to plants in gardens, greenhouses, or mushroom cellars, but they are probably most important in the transformation of organic material in upper layers of soil.

Cross section of a spore of a microsporidian species found infecting a Collembola. The actual size is 5 microns long (Photo by Joseph Maddox).

Until recently microsporidian parasites, common in most groups of insects, had never been reported from Collembola. The microsporidia are a group of tiny animals having infectious spores which are typically between 3-10 microns in length. They are obligate parasites, primarily of invertebrates. Survey researcher and Collembolan taxonomist, J. A. Mari Mutt several years ago observed that a few Collembola specimens in the extensive Natural History Survey collection of Collembola had thousands

of small refractive oval bodies in muscle and fat body tissue. In cooperation with insect pathologists, J. V. Maddox and V. Brunjes, Mari Mutt removed the Collembola containing these small oval bodies from the glass slides on which they were mounted. They were then processed for transmission electron microscopy, sectioned, and viewed under an electron microscope. This is the first time microsporidia have been recovered from mounted museum specimens.

Microsporidian infections were found in five different species of Collembola in the INHS collection. Two specimens were collected in Algeria, the other three in France, Portugal, and the Dominican Republic. Before the publication of this study, microsporidia were also reported from seven species of Collembola, all collected in the Federal Republic of Germany. The discovery of seven species of microsporidia-infected Collembola in the Federal Republic of Germany and five infected Collembola in the INHS museum, collected from diverse locations, suggests a rich source of undescribed microsporidia in the Collembola.

This is especially interesting to Microsporidia and Collembola taxonomists as several of the microsporidia found in Collembola are quite unusual and the Collembola, belonging to the sub-class Apterygota, comprise a primitive group of animals long isolated phylogenetically from other insects. In fact, many systematists think the Collembola are a separate group between the Insecta and Myriapoda. It will be interesting to compare microsporidia from Collembola with microsporidia from the Myriapod classes according to researchers at the Survey.

Kentucky Cave Shrimp

With more than 250 species of animals recorded, the Flint-Mammoth Cave System in Kentucky is believed to be the most biologically diverse cave in the world. At least 50 of the species are troglobites or troglophiles: A troglobite is an organism which to survive must spend its entire life in a cave; a troglophile is an organism which may, but is not obligated to, spend its entire life in a cave.

The Mammoth Cave region has such a high diversity of life because of the diversity of cave types, habitats, food types, and geographic sources of the fauna. In this "ecological theater," the evolution has involved both local species and those that have migrated in from three adjacent cave regions. Three species of cave fishes come from the three regions and co-occur only in the base level stream passages of Mammoth Cave. The Kentucky Cave Shrimp, in contrast, evolved locally and is unique to the Mammoth Cave System.

The shrimp have evolved a life cycle which requires their isolation in pools near base-level rivers. As the annual winter floods recede, the shrimp, which probably lives only one or two years, seeks isolated pools above the low-water level. The organic veneer, deposited by winter floods, provides a propitious habitat for microorganisms, which are the main food of the shrimp. A favorable food supply as well as protection from predation allow the shrimp to mature during the summer, and allow the newly hatched young to develop sufficiently before the annual winter floods begin. The shrimp's small population size, limited distribution, and specialized requirements make it extremely vulnerable to habitat disturbances. They are, therefore, considered to be an indicator species of the health of the entire aquatic ecosystem in the base level rivers of Mammoth Cave.

In 1901, William Perry Hay first discovered the shrimp in a series of small pools, now known as the Shrimp Pools, in Roaring River of Mammoth Cave. In

Kentucky Cave Shrimp is rare and difficult to locate (Photo by Ed Lisowski).

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1928, during their expedition to caves of North America, the prominent European cave biologists, Candido Bolivar and Rene Jeannel found shrimp in a pool near Echo River and, in 1929, Leonard Giovanolli found shrimp in isolated pools associated with nearby Styx River. Biologists did very little in the cave from 1930 to 1950, but during the 1950's and until 1967, the Kentucky Cave Shrimp usually could be found in the Shrimp Pools as well as in small pools near the Golden Triangle, a base level stream several miles from Roaring River but still part of Mammoth Cave. Since the shrimp were not seen again during the subsequent 12 years, they were feared extinct.

Disturbances of the aquatic habitats in Mammoth Cave may have caused the decline in populations of the shrimp from these historic localities. Pollution, both from leaking sewage lagoons within Mammoth Cave National Park and from sources outside the park have had a negative impact on cave rivers. Dams on the Green River have modified the habitat and altered the flooding cycles of the cave rivers. The pool behind one dam extended into some of the cave rivers, which permanently flooded many of the once seasonally isolated pools, increased siltation, and disrupted nutrient flow into the cave. All three dams altered the flooding cycles by decreasing the intensity of winter flooding and increasing the frequency of summer flooding. This may have impacted the shrimp by disrupting its reproductive cycle, which is synchronized with winter flooding, and by reducing the feeding time in quiet pools for both adults and newly hatched young.

Between May 1979 and September 1981, Survey scientist Ed Lisowski searched on a monthly basis for shrimp at their historically known localities. After finding one dead shrimp in the Shrimp Pools in September 1979, he arranged for cave scuba divers to look for shrimp in the deep pools of Roaring and Echo rivers and in submerged cave passages. During four dives between October 1980 and January 1981, they found a total of 17 shrimp, and in January 1981, Lisowski found three shrimp in the Golden Triangle.

These data demonstrate that, although not extinct, the Kentucky Cave Shrimp is rare. The U.S. Fish and Wildlife Service has accepted a petition to begin the process of listing the shrimp as a federally endangered species, and the National Park Service funded a 2-year study of the shrimp's biology and distribution so that the Service could develop a management program to conserve the shrimp. Lisowski has volunteered his time to assist with the study. The USFWS has delayed the final determination of the status of the shrimp until the completion of the study in October 1983.

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The Declining Grassland Birds

Until at least 1959, populations of grassland species of birds in Illinois were remarkably preserved, considering that the original prairie was all but gone and had been for many decades. It was true that the sharp-tailed grouse had been extirpated, that the greater prairie chicken was greatly reduced, and that the Eskimo curlew — a once abundant transient of the Illinois prairie — was near extinction, but song birds of the prairie were surviving. They had adapted well to the mixed agricultural practices of the day.

Censuses in 1957 and 1958 across the north, middle, and south of Illinois by Drs. Jean and Richard Graber of the Survey's Wildlife Research Section showed that breeding populations of the prairie species of song birds were nearly as numerous (or even more numerous in some cases) as in 1906-1909 when the first cross-country transect censuses were made for the Illinois Natural History Survey by Alfred O. Gross and Howard Ray. For example, there were about 4,000,000 birds of the two meadowlark species in Illinois in 1906-1909 and 3,800,000 in 1957-1958, about 1,200,000 bobolinks in 1906-1909 and 1,900,000 in 1957-1958; and about 1,700,000 dickcissels in 1906-1909, and 3,400,000 in 1957-1958. Hayfields and pasturelands were providing adequate habitat for these and other grassland species in Illinois.

After 1960, farming practices changed rapidly with increasing specialization and emphasis on the production of corn and soybeans. The managed grasslands that had supported populations of prairie birds dropped precipitously in acreage — as much

Male bobolink (left) and female bobolink in grassland nesting habitat (Photos by Richard and Jean Graber).

as 50 percent per decade, and it was clear that grassland species of birds were declining. Populations of birds cannot increase their densities in a dwindling area of habitat, but if such an ability existed, Illinois provided a supreme test case in the 1960's and 1970's. Censuses were needed to see precisely what was happening. When the 70th anniversary of the first series of censuses arrived, the Grabers were completing a study of heron populations in the state, but in 1978 and 1979 they censused as much grassland habitat during the nesting season as they could cover in the time available. It was difficult to find enough grassland to census, but ultimately about 450 acres were censused in northern and central Illinois. The results were surprising, for population densities of almost every grassland species had fallen 80-90 percent below those of 1957-1958. Combining density loss *and* habitat loss, total population loss among grassland species of birds has been catastrophic. Total losses for representative grassland species are shown in the table. Because southern Illinois is south of the range of some prairie species, the data refer to northern and central Illinois only.

Species	Population Loss Since 1957-1958 (%)
Upland Sandpiper	—92
Bobolink	—97
Meadowlarks (2 species)	—84
Dickcissel	—96
Grasshopper Sparrow	—96
Savannah Sparrow	—98
Henslow's Sparrow	—94

When we consider that such great changes occurred in about 20 years — only a brief moment in the history of a wild population — the figures are alarming. A large decline was expected because of habitat loss, but why did the densities decline? Have qualitative changes occurred in the habitats? Or do the problems of the grassland birds lie along the migration routes, or on the winter ranges of the various species? The group includes species which winter south of the equator in South America (Bartramian sandpiper and bobolink), in Central America (dickcissel), and along the Gulf coast of the United States and Mexico (grasshopper and savannah sparrows). Are there problems for the species in all these places and in Illinois too?

The answers require intensive field work not yet begun, but, obviously, no population can endure such losses for long.

Pesticide Biodegradation: Too Much of a Good Thing?

Over the last 25 years soil insecticides have become an important tool in the control of soil insect pests. Almost 50 percent of the corn acreage in Illinois (about 6 million acres) is treated at planting time with an insecticide. In general, these tools have been very effective in reducing root damage caused by heavy infestations of corn rootworms in fields planted to corn in consecutive growing seasons. However, during this period a few of the insecticides have performed poorly or inconsistently. It would be a simple matter to switch to more effective chemicals, but the rate of introduction of new insecticides has slowed considerably. The arsenal of soil insecticides is becoming more limited, especially when one considers that the currently used products generally lack chemical diversity.

Within the last 15 years a gradual change has occurred in the kinds of soil insecticides used. In the 1950's and 1960's the chlorinated cyclodienes (i.e., aldrin, heptachlor, and chlordane) were commonly used for soil insect control throughout the Midwest. The use of these chemicals was eventually discouraged and then suspended because they persisted in the environment for excessively long times and tended to accumulate in biological tissue. The organophosphate and carbamate insecticides slowly replaced the cyclodienes. These chemicals degraded quickly in the environment and were shown to have a low tendency for bioconcentration. On the other hand, the organophosphates and carbamates are generally less active against insects in soil than the chlorinated cyclodienes. Thus, changing chemical usage patterns have demanded extensive study of the principles affecting the environmental and toxicological behavior of soil insecticides. One research area gaining more attention centers on performance problems of soil pesticides.

Survey entomologist and insecticide toxicologist, Allan Felsot, has been investigating the cause of soil insecticide performance problems. Entomologists are quick to suspect the development of insecticide resistance when an insecticide performs poorly. Corn rootworm beetles developed resistance to the chlorinated cyclodienes in the 1960's, but monitoring of different rootworm beetle populations in Illinois during the last three summers failed to show any relationship between insect susceptibility to carbofuran and control efficacy. Research from other states also indicated that the susceptibility of the corn rootworm to various insecticides had not changed significantly over the last decade. These results led to a second explanation for insecticide performance problems based on the potential of the currently used products to degrade rapidly in soil. An effective soil insecticide must be present at a toxic concentration from 1 to 2 months following application because the corn rootworm does not hatch and start feeding in Illinois until early June. In several soils that were collected from northwest Illinois, carbofuran insecticide completely degraded with-

in 30 days. These soils were collected from fields where the chemical had been used for several consecutive years before a control failure was noted. Further studies indicated that the insecticide was being degraded by microorganisms which had proliferated in this soil. Apparently, some groups of soil microorganisms use added pesticides as nutrient or energy sources and thereby greatly expand their populations. When a soil containing these conditioned microbial populations is retreated, the pesticide is degraded at a very rapid rate and its concentration falls below the level necessary to kill the insects. At present, it is not known which soil types contain microorganisms capable of adapting to the pesticide, nor exactly which pesticides are susceptible to this rapid biodegradation. Further studies are being conducted to characterize this phenomenon and its implications for the chemical control of the corn rootworm in the Corn Belt.

Transplanting New Trees

Transplanting is a major operation from which most plants recover slowly, even when growing conditions are ideal. Normally, a tree maintains a certain balance between its top and root system. Water and nutrients are taken in through the roots to supply the plant with elements necessary for food production in the leaves. The transplanting operation, regardless of how carefully it is performed, is destructive to a large portion of the absorbing root area. Once the roots are severed during the digging operation, the tree is in varying degrees of water stress until new roots are regenerated and able to absorb the necessary water and nutrients from the soil.

In studies conducted in the Survey's experimental tree nursery, up to 98 percent of the root system of trees 3-6 inches in diameter is removed in the transplanting operation when the soil balls are as much as 4 feet in diameter. Smaller soil balls will contain even fewer original roots. The study also showed that the density of fine roots was greatest in the top 4 inches of soil and that the large main structural roots were predominantly located at the soil depth of 5-13 inches, with limited development in the top 4 inches and decreasing development at depths below 13 inches. In general, most tree species tending to be more deeply rooted are not as tolerant to heavy clay soils having seasonal high water tables, a condition which often exists in many urban soils. These field studies gave substantial evidence of the shallowness and importance of the development of the fine absorbing root system of transplanted trees.

Careful preparation is made for transplanting a tree (Photo by Eugene Himelick).

In lawn areas, it has been shown that competition from grass is an important factor limiting the development of the shallow tree roots. This evidence supports previous work in which mulching the soil around trees increases the fine root development by reducing or eliminating grass competition and by helping maintain adequate soil moisture and aeration in the upper soil layer.

A guide to the ease of moving various tree species and the best season to transplant them was recently prepared and is available upon request. Those tree species difficult to transplant should receive the utmost care during transplanting and continued maintenance after transplanting. Spring planting of most tree species has the advantage of ample soil moisture and avoids the possibility that sufficient roots may not become established before freezing weather. If trees cannot be planted before they start leafing out, it is essential for most tree species to wait until after the early rapid spring growth has slowed before moving trees in leaf.

Watering of recently transplanted trees was found to be the most important main-

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tenance practice, and under normal urban soil conditions, overwatering frequently caused more root damage than if the trees had not been watered at all. Watering should be done at the time of planting to assure adequate soil moisture in the soil ball and the soil filled around the soil ball. Following the first watering, additional water should be provided only when there has not been sufficient rain to keep the soil moist. The critical months for watering are May through September and for 2-3 years after transplating to assure that the root systems are well established. For slow-growing trees, a period of prolonged drought even during the second or third year can cause severe water stress and make them very susceptible to attack by bark borers and development of trunk cankers caused by various fungi. A newly planted tree is most easily watered if a mound of soil 4 inches high is prepared around the edge of the original planting hole. The mound of soil serves as a reservoir that should be filled with 6-8 gallons of water at 7- to 10-day intervals during the dry periods of the growing season. Urban soils are frequently high in clay subsoil and tend to drain poorly. Under these conditions, allowing the water hose to run for prolonged periods of time in the reservoir can result in overwatering and cause the roots to drown from lack of adequate soil aeration.

Extensive field surveys of recently transplanted trees have shown that the homeowners are largely responsible for the death and general poor vigor of their trees. Poor tree selection, poor planting stock, and improper planting were frequent causes for early decline and death of trees. Improper watering, lawnmower damage, and injury from weed killers used on the lawn were found to be common causes of decline after the trees were transplanted. Researchers in the Section of Botany and Plant Pathology of the Illinois Natural History Survey are willing to offer advice on various tree problems if you wish to write or call.

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Natural History Survey To Observe Anniversary

On June 30, 1858, the Natural History Society of Illinois was organized at Bloomington in the office of the Illinois State Normal University. The same organization has become, after several transformations through the years, the Illinois Natural History Survey, located in the Natural Resources Building in Champaign.

This year marks the 125th anniversary of this organization. Because of circumstances preventing the attendance of many friends of the Survey in June, the celebration dates have been moved to the end of September. Plans are being made for a symposium to be held on Saturday, September 24. There will be a luncheon at the Illini Union and a more informal meal in the evening.

On Sunday, September 25, there will be an Open House and the Survey and its annex facilities, and many of the scientific research projects, will be shown and explained to visitors.

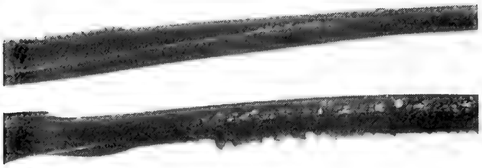
On Friday, September 23, preceding the Saturday symposium, a chartered bus tour will take members of the staff and the public to visit three field stations; Kinmundy, where the aquaculture project is in progress; Bogota, the home of the prairie chicken research; and Sullivan, where aquatic biologists conduct their work on Lake Shelbyville. Participants will take a sack lunch and pay their own bus fares, the amount of which has not yet been determined.

Inquiries about the anniversary celebration may be directed to Shirley McClellan, general chairman and coordinator of anniversary events, at 217-333-6882.

Corn Damaged by Stalk Borers

The stalk borer, *Papaipema nebris,* has not been a serious pest of seedling corn in the midwestern United States since the 1930's, but recent increases in conservation tillage have led to a greater incidence of stalk borer problems. Female moths lay eggs primarily on grasses in fence rows, contour strips, grass waterways, or in weedy fields during the late summer and early fall. The eggs do not hatch until the following spring. At that time, larvae first begin feeding on grasses but move to larger plants as they outgrow their original hosts.

In conventionally tilled fields, damage by the stalk borer is generally confined to the first four to eight rows of corn that are adjacent to field margins, contour strips, and grass waterways. In Illinois, larvae have been found moving into fields of corn and attacking seedlings any time from crop emergence through the end of July. In corn fields where minimum tillage, particularly no-till, is practiced, serious infestations can occur throughout entire fields. When infested fields are planted using a no-till system, herbicides used to kill the existing weeds force the young larvae to move to the only remaining food source — the corn seedlings. Corn plants attacked by the stalk borer may become misshapen or stunted, severely damaged plants usually die. Even if plants survive, they generally produce less grain than uninjured plants.



Stalk borer larva (top) feeding in giant foxtail stem. When the larva outgrows its original host plant or its host plant is killed with a herbicide, the insect may move to corn. Stalk borer eggs on quackgrass (bottom) (Photo by Eli Levine).

Eli Levine, a Survey entomologist, conducted laboratory studies to determine temperature thresholds and thermal requirements (degree-days) for stalk borer development. He found that 50 percent of the eggs hatched when 329 heat units accumulated above a threshold temperature of 47°F and that total development from egg to adult moth was completed by 50 percent of the individuals when 3,504 heat units accumulated above an overall developmental threshold temperature of 41°F. Levine also showed that female moths began laying eggs three days after emergence from pupae. These laboratory data were validated with data on egg hatch in an outdoor screenhouse and on moth catches in a light trap. The results showed that the dates of one-half the egg hatch under screenhouse conditions and one-half the moth capture by light trap were within one and seven days, respectively, of predicted dates based on laboratory data.

Knowing when common stalk borers hatch and when adults lay eggs will be a help in the control of this pest. Destroying weeds in noncrop areas prior to egg hatch can not be recommended because the cover is needed for beneficial insects and it helps combat soil erosion. However, growers may wish to mow these noncrop areas just prior to stalk borer egg laying and thus make the areas less attractive to moths. These areas, however, should not be mowed between planting and early July since this practice just drives the larvae into the corn and makes problems even worse.

In no-till fields, herbicides used to kill existing vegetation in spring force the young larvae over to the emerging corn. To reduce the potential of this occurring in a subsequent season, good weed control within a field is essential prior to the egg-laying period of the moths (usually from mid-August through mid-October in northern Illinois). Levine is currently working on other cultural and chemical control strategies to combat this pest.

Some Effects of Air Pollutants

Gardening, like most things, is largely what you make of it — a hobby, a serious pursuit, a game, an art, a science, or a tedious chore. It can be an infinite pleasure or a vital concern. Whether your interest is for ornamental shrubs, cut flowers, or vegetables, successful gardening requires some knowledge of plant care basics — soil texture, moisture and drainage, pH, nutrition, sunlight, weed and pest control, temperature requirement — and availability of species and varieties to the home gardener. However, many gardeners overlook air pollution which interacts strongly with gardening.

Since most people live in or near urban areas, much gardening is concentrated where pollution levels tend to be high as a result of transportation systems, space heating, industrial activity, and other human-oriented activities. Gardening also creates its own pollution problems from the need for frequent and sometimes heavy use of pesticides and fertilizers.

The role of gardening in providing attractive, safe, and nutritious fruit and vegetable foods or an aesthetically pleasing landscape is beset with pollution problems. Air pollutants, such as ozone, sulfur dioxide, fluoride, nitrogen oxides, and other forms of pollution may visibly injure plants, reduce growth rates and yield, and impair homeowner or consumer acceptance.

According to Natural History Survey Botanist Anton G. Endress, when any air pollutant impinges on plants, many factors

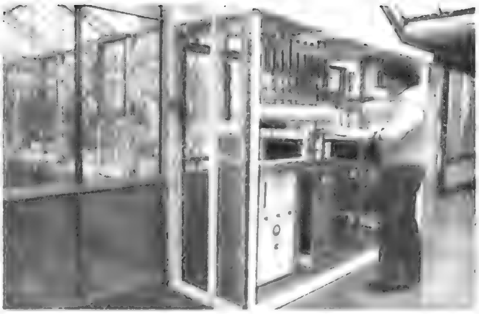
come into play to determine what effect the pollutant will have on the vegetation. A wide range of effects is possible, depending on the interaction of the biological characteristics of the plant species, the nature of the pollutant, and the environmental conditions.

The tolerance or sensitivity of vegetation to pollutants depends on (1) genetic makeup, (2) age, health, vigor, and state of metabolic conditions, and (3) rate of pollutant uptake and accumulation. The varying sensitivities of individual plants to pollutant injury may be due to differences in genetic constitution which controls the biochemical and physiological tolerance for the pollutant. Leaves at different stages of development also may show different degrees of sensitivity to the same pollutant.

The nature of a pollutant is defined by its chemical characteristics and its persistence. The response of vegetation to air pollution depends on the pollutant concentration and length of exposure time. High concentrations of pollutants often produce an immediate and acute impact with some easily recognized symptoms. Low concentrations, however, produce more subtle or chronic effects that develop gradually and are not readily identifiable. If plants are exposed to a pollutant mixture, the total effect may be synergistic, additive, or antagonistic.

Plant response to air pollutants is partially controlled by a number of environmental factors such as temperature, light, relative humidity, soil moisture, nutrient status, and time of year. Generally, the environmental conditions that are most favorable to plant growth also produce the maximum air pollution response. Other factors such as wind direction and speed, and temperature inversions, are also important because they determine the dispersal and dilution of the pollutants.

Vegetation weakened by stresses such as adverse climatic conditions, a nutrient deficiency, or disease and insect disorders responds to air pollution much more readily and severely than healthy vegetation. Plants under stress before even mild air pollution episodes may not possess an adequate defense mechanism to protect themselves against pollutant injury. Similarly, plants suffering air pollutant stress may be predisposed to attack by insect or fungal pests.



Botanist Anton Endress checks data from a nine-chamber pollution exposure system with various monitors, greenhouses, and controlled growth chambers (Photo by Les Woodrum, Survey Photographer).

The significant characteristics of the symptoms caused by ozone and sulfur dioxide are outlined below.

Ozone

Leaf markings are divided into three categories by plant type: (1) broadleaf plants — pigmented (red-brown) spots or bleached tan to white areas on upper surfaces of leaves; small irregular areas of dead tissue on both leaf surfaces that may coalesce to form large blotches; chlorosis and premature aging may occur, (2) grasses — scattered necrotic areas on both leaf surfaces; sometimes larger lesions or necrotic streaking may occur, and (3) conifers — brown-tan necrotic needle tips without separation between dead and healthy tissue.

A. Sensitive garden species or cultivars

Beans (especially white flower varieties, such as Pinto, Tempo, Sanilac, Bush Blue Lake 274), corn (especially Golden Midget, Golden Jubilee), cucumber, eggplant (wide range of sensitivity between cultivars), lettuce (especially Dark Green Boston, Grand Rapids Forcing, Buttercrunch), muskmelon, onion, potato (especially Chippewa, Cobbler, Plymouth), radish (especially Cherry Belle, Crimson Giant, Comet, Champion), spinach, tomato, grape (wide range of sensitivity), alder, crabapple, bridalwreath, honey locust, lilac, eastern white pine, privet, snowberry,

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sycamore, begonia (especially white flower varieties, such as White Comet, Cinderella White), carnation, chrysanthemum (especially Tranquility, Mt. White, Mango, King's Ransom, Touchdown, Corsage Cushion, Gay Blade), petunia (especially white flower varieties, such as Snowstorm and White Cascade).

B. Similar Markings

Red spider mite and certain insects may cause an upper leaf surface fleck of bleached tan to white areas. Some leafspot fungi may give similar patterns. Pathogen-induced tip burn in conifers may resemble ozone injury.

Sulfur Dioxide

Leaf markings are divided into three categories by plant type: (1) broadleaf — irregular bifacial (both sides), marginal, and interveinal necrotic areas bleached white to tan to brown; chlorosis may be associated with necrotic areas or a general chlorosis of older leaves may develop; diffuse to stippled colors ranging from white to reddish-brown have been observed, (2) grasses — irregular, bifacial, necrotic streaking between larger veins that is bleached tan to white; chlorosis not usually pronounced, and (3) conifers — brown necrotic tips of needles often with a banded appearance; generally chlorosis of adjacent tissue; needles of the same age are uniformly affected.

A. Sensitive garden species or cultivars

Bean (table), beet, broccoli, Brussels sprout, carrot (very few cultivars have been tested), endive, lettuce, okra, pea, pepper, pumpkin, radish, rhubarb, spinach (wide range of sensitivity among cultivars), squash, Swiss chard, turnip, apple (especially Golden Delicious), currant, birch, larch, mulberry, pear, eastern white pine, Lombardy poplar, aster, bachelor's button, begonia (especially White Comet), cosmos, four-o'clock, morning glory, sweet pea, tulip (especially American Flag, Grand Hotel, Gold Medal, Red Shine, Queen of Night), verbena, violet, zinnia.

B. Similar markings

Leafhopper injury, rose chafer injury, various mosaic viruses, cherry leafspot, and other fungal disease producing blotchy markings; winter, drought, and red spider mite injury in conifers.

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NATURAL HISTORY SURVEY REPORTS

The Natural History Survey Celebrates 125 Years of Biological Research

One hundred twenty-five years of biological research have been completed by the Illinois Natural History Survey, which will celebrate this anniversary September 23 through September 25.

A 125th Anniversary Symposium will be held on Saturday, September 24, in the Medical Sciences Building on the University of Illinois campus and will be open to the public. Featured speaker at the luncheon in the Illini Union will be Dr. Lorin I. Nevling, Director of the Field Museum of Natural History, Chicago. Several "Friends of the Illinois Natural History Survey" will be honored at this time. A limited number of luncheon tickets are available at $8.00 each.

Two researchers of "the olden days," Charles A. Kofoid (front) and Miles Newberry, traveled the Illinois River bottoms at high water in the early 1900's.

On Sunday, September 25, an open house will be held from 1 p.m. to 5 p.m. at both the Natural Resources Building and the Natural Resources Studies Annex located on the south campus of the University of Illinois. The insect, plant, fish, and other collections will be open to visitors in the Natural Resources Building. Special projects in progress will be on display and will be explained by researchers in the Annex.

To open the three-day anniversary celebration, on Friday there will be a bus tour to three field stations, Bogota, where prairie chicken research is being conducted; Kinmundy, where aquaculture projects are in progress; and Lake Shelbyville at Sullivan, where aquaculture biologists are conducting various studies. The bus will leave at 8 a.m. from the Natural Resources Building in Champaign and will return there about 5:30 p.m. Lunch will be provided at Kinmundy (hot dogs, potato chips, and beverage) or participants may bring their own "brown bags." The bus fare will be $12.00 payable to the Survey when a reservation is made.

Inquiries about the 125th Anniversary Celebration should be directed to Shirley McClellan, Anniversary Events Coordinator, 172 Natural Resources Building, 607 East Peabody Drive, Champaign, Illinois 61820, or call (217) 333-6882.

Bulletin to Publish Symposium Papers

Distinguished scientists of the Natural History Survey and from universities and other research organizations will present papers at the symposium, and these papers will be published in a special 125th Anniversary Symposium Proceedings issue of the *Illinois Natural History Survey Bulletin*.

Among the speakers at the symposium will be Dr. D. H. Janzen, Department of

Biology, University of Pennsylvania, whose topic will be "The Other Reasons Why a Plant Is a Good/Bad Host: The Plant as a Habitat." Dr. C. R. Goldman, Division of Environmental Studies, University of California, Davis, will speak on "Lake Tahoe, a Microcosm for the Study of Change as the Basin Is Developed."

Speakers from the Illinois Natural History Survey in the morning session include Dr. R. L. Metcalf, speaking on "Plant Karimones and Insect Pest Control": Dr. A. S. Felsot, who will have as his topic "The Evolution of Environmental Awareness Through Pesticide Chemistry and Toxicology Research"; and Drs. R. D. Neely, D. F. Schoeneweiss, and E. B. Himelick on "Biotic and Abiotic Stresses as Primary or Predisposing Factors Affecting Illinois Trees."

In the afternoon session, Survey speakers will be Dr. D. P. Philipp, whose topic will be "Application of Genetic Techniques to Fisheries Management"; Dr. L. M. Page, speaking on "The Evolution of Reproductive Behaviors in Percid Fishes"; and Mr. W. E. Cochran presenting "Wind Drift and Migration of Passerines."

The *Illinois Natural History Survey Bulletin* containing the Proceedings of the 125th Anniversary Symposium will be published in the spring of 1984.

Early History of the Survey

The beginnings of the Illinois Natural History Survey go back to December 1857, when Cyrus Thomas of Carbondale proposed to the State Teachers' Association that a Natural History Society of Illinois be established. On June 30, 1858, the Society was organized at the Illinois State Normal University. The constitution provided that specimens should be collected and deposited in the museum of the State Normal University.

The state charter awarded to the Natural History Society in 1861 authorized the Society to establish its own museum at the State Normal University. In 1871, as a condition for receiving financial assistance, the Society relinquished ownership of the museum to the state. The Illinois legislature in 1867 established the State Entomologist's Office, and 10 years later authorized

Dr. Stephen A. Forbes

changing the Illinois Museum of Natural History at Normal to the State Laboratory of Natural History.

Stephen Alfred Forbes, who later became the first Chief of the Survey, was both Director of the State Laboratory of Natural History and State Entomologist in 1885 when he moved from Normal to Urbana to accept an appointment as professor of zoology and entomology at what was then the Illinois Industrial University.

Later in the same year the legislature approved the transfer of the Laboratory from Illinois State Normal University to the University of Illinois. Thus, both the State Laboratory of Natural History and the State Entomologist's Office became located in Urbana. There they continued as separate units until 1917, when the General Assembly combined them as the Illinois Natural History Survey to carry on the intensive program of biological research begun 60 years earlier.

There are those who speculate about the name, Illinois Natural History Survey. Chief Forbes believed that "survey" meant more than mere plant and animal censuses. He felt that any study should show the relationships between living organisms and their environments . . . an ecological sur-


Dr. Frison


Dr. Mills


Dr. Sprugel

vey. This theory prevailed in all his work and firmly underlined the research done at the Illinois Natural History Survey.

Stephen A. Forbes Led the Way

Dr. Harlow Mills wrote of Forbes in the 100th Anniversary Bulletin:

"No one has molded the character of the Illinois Natural History Survey so much as Dr. Stephen A. Forbes, a man of irrepressible intellect and insatiable curiosity, and the fourth and last Illinois State Entomologist . . .

"After the resignation of Cyrus Thomas as State Entomologist in 1882, Governor Shelby M. Cullom appointed Forbes to that position. In 1884 Indiana University awarded Forbes the Ph.D. degree by 'thesis and examination.' He did not have a bachelor's degree. In 1885 he moved to the University of Illinois, where he was Professor of Zoology and Entomology, Director of the State Laboratory of Natural History, and State Entomologist . . .

"He was especially interested in the interactions of organisms and has been called 'the father of ecology.' His interest covered all of biology. He investigated or directed investigations of the food of fishes and birds, the fishes of the state, and the biology of the Illinois River, and he directed forest surveys of Illinois . . .

"He was a member of many learned societies and the recipient of many honors. Beyond this, he was active in his church, helped organize the first golf club at the University, was a member of a hiking club, and late in life delighted in driving an automobile. On his eightieth birthday he was arrested for speeding, an incident which gave him some pleasure . . .

"When the State Laboratory of Natural History and the State Entomologist's Office were united in 1917 to form the Illinois Natural History Survey, Forbes became the first Chief of the new organization. He held this position until his death, March 13, 1930, when almost 86 years of age."

Survey Chiefs Through the Years

The Natural History Survey has been very fortunate in having a series of outstanding men who served as Chiefs. Each in his own way has contributed to the


Dr. Paul G. Risser

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growth of the Survey, economically, scientifically, and philosophically.

Theodore H. Frison (1931-1945) grew up in Champaign-Urbana, and as a personal friend of Dr. Forbes, he knew the needs of the Survey long before he became its Chief. Along with Dr. M. M. Leighton, Chief of the Geological Survey, he concluded that the two Surveys had outgrown the space allotted to them in the Natural History Building on Green Street. The two men were able to obtain the land and funds for the Natural Resources Building, which the Surveys moved into in 1940. This was the Natural History Survey's first permanent home.

Frison, whose specialty was bees, had many interests. As soon as he became Chief, he began the development of wildlife research as a separate discipline. He was instrumental in organizing the Midwest Wildlife Conference, the initial meeting of which was held in Urbana in 1935. He was also a charter member of the Wildlife Society.

In intellect and aggressive enthusiasm, he was a worthy successor of Forbes.

A coworker cited Dr. Harlow B. Mills' (1947-1966) greatest achievement as that of "welding together the Survey into a marvelous cohesive scientific structure." The staff had more than doubled, the research budget had increased by more than 225 percent, and areas of living natural resources were being explored in depth. Dr. Mills' success in developing the Survey was partly due to his knowledge of both entomology and wildlife combined with his remarkable ability to get people to cooperate.

George Sprugel, Jr. (1966-1980) came to the Survey from the National Park Service in Washington, D.C., where he was Chief for the Division of Natural Sciences.

His outstanding contributions to the growth of the Survey included the building and instrumentation of the Natural Resources Studies Annex south of St. Mary's Road in Champaign, the development of an extensive grant and contract program, and the expansion of eight field stations around the state.

During a very trying time in the state's economy, Dr. Sprugel was able to keep the staff intact and maintain the quality of scientific research at a high level.

Relatively new to the Illinois Natural History Survey is Dr. Paul G. Risser, who came here in June 1981 from Norman, Oklahoma, where he was chairman of the department of botany and microbiology at the University of Oklahoma. A dynamic and energetic man, he has implemented a number of his ideas for making the Survey a smoother operating, more productive organization.

To date, he has installed a sophisticated word-processing and computer system, increased the grants and contracts program, and is continually working to strengthen Survey relationships with other state agencies.

On seeing him in operation, one knows that he has only just begun. . . .

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NATURAL HISTORY SURVEY REPORTS

"Friends of the Survey" Honored

Six "Friends of the Illinois Natural History Survey" — Gaylord Donnelley, Leonard Durham, Murray O. Glenn, Marion Hall, Sam A. Parr, and Robert Webb — were honored at the Survey's 125th Anniversary Symposium Luncheon held on September 24 in the Illini Union Building. Framed certificates designed by Survey Illustrator Lloyd Le Mere were presented to the honorees.

Gaylord Donnelley has demonstrated his friendship and concern for conservation, research, and the arts on an international, national, and state scale by his financial support and by serving on many boards and commissions on all three levels.

Leonard Durham, Director of the Division of Life Sciences at Eastern Illinois University, has sent more than 200 student interns to work at the Survey.

Murray O. Glenn, whose certificate was accepted by members of his family, died in 1981 at the age of 87. He spent 46 years studying the Lepidoptera (butterflies and moths) in his free time. His collections of 30,000 specimens presented to the Survey have contributed significantly to the classification and study of ecology of moths in the Midwest.

Marion Hall, Director of the Morton Arboretum at Lisle, provided an insectory; he even provided housing for members of the Survey staff while they were working there. Hall has also assisted in getting funds for Survey research.

Sam A. Parr started as a game warden, but as he advanced in the Department of Conservation, he provided close cooperation, support, and friendly help for wildlife and fisheries studies at the Survey.

The sixth honoree is Robert Webb, former Director of the Dixon Springs Agricultural Station at Simpson. He hosted and in many ways encouraged research on the Experiment Station lands, ponds, and forests.

Domestic Cats in Rural Illinois

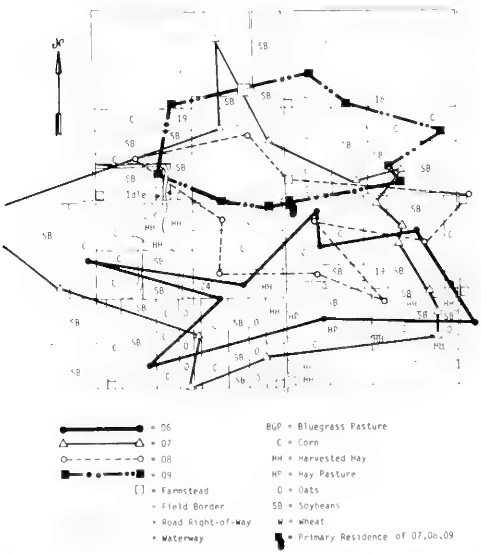
The few available facts pertaining to domestic cats in the United States suggest that these feline pets may have increased by as much as 65 percent over the past decade. The pet food industry estimates that there are about 42 million cats in this country. However, these estimates have been derived primarily from human-cat ratios for metropolitan areas. What are typical densities of these felines for rural areas? Do they significantly affect wild animal populations? In a preliminary 5-year study of a rural cat population in Illinois, wildlife ecologist Richard Warner addressed these questions.

The primary study site was a 20-square-mile area located between Sibley and Melvin in Ford County. With the cooperation of rural residents of the area, the demography of their cats was studied, 1976-1981, with emphasis directed toward the late summer population. To compare numbers of cats in this area with those living in other parts of rural Illinois, early morning roadside transect counts were conducted on this area and four other townships in central Illinois, 1977-1981. Further, the Illinois Department of Conservation provided cat census data from spring roadside counts of mammals along approximately 40 different routes throughout rural Illinois, 1981-1983. In conjunction with census work on the primary

study area, 11 cats were fitted with small, lightweight radio transmitters and were radio monitored during summer and early autumn.

Over the 5-year period, there was an average of 5.6 cats per residence in the Ford County area in late summer. Breeding females averaged 1.5 per residence with little annual variation, because residents tended to limit numbers of actively breeding females. Late summer cat densities ranged from 10.4 to 22.4 per square mile and averaged 16.3 cats per square mile from 1976 to 1981. Farmsteads with livestock typically had three times as many cats as residences without large animals had.

Warner found no evidence of feral cats — felines reproducing in the wild and avoiding or rejecting domestication and domestic food sources. Only 5-10 percent of the cats survived to 3 years of age, with less than 1 percent surviving to 7 years. From deaths documented by cat owners in the Ford County area, 1979-1981, road kills accounted for 26 percent of the mortality, and dispersal or disappearance and disease each accounted for 17 percent of the deaths. Humans, dogs, cats, and winter weather were also common feline killers.



Ranges of four domestic cats radio tracked in Ford County during July and August 1978. Male 06 tended to be vagrant during the period of study, having no permanent residence and avoiding farmsteads except for feeding. Females 08 and 09 were pregnant during the radio-tracking period.

Radio tracking of seven females indicated a typical summer range of 278 acres, with females commonly roaming within a radius of about 0.9 mile from their residences. Male cats evidenced greater movements, with four radio-monitored males averaging 563 acres of range; they were commonly found within a radius of 1.3 miles from their residences. Ranges of mature males tended to be separate from those of other sexually active male cats. A group of females and juvenile males at a given farmstead generally had overlapping ranges within the territory of one mature male (see map). Excluding farmsteads, 73 percent of the radio-location points for the 11 monitored cats were in some form of linear habitat or edge (ecotones that were highly attractive to wildlife) such as field edge, waterways, or roadsides.

All cats in the Ford County area fed regularly at residences, but they also hunted, at least to some extent. In fact, all radio-monitored cats hunted, primarily between 6 p.m. and 6 a.m. when temperatures were relatively cool and dew was present. During 1978 and 1979, residents noted prey brought to farmsteads by their cats; 77 percent of the residences reported rodents; 12 percent, other small mammals; 13 percent, cottontail rabbits; 9 percent, pheasants; and 43 percent passerines or other small birds. The evidence suggests that well-fed cats hunt regularly, compete with other predators of small animals, and destroy desirable forms of wildlife.

The data from this preliminary study indicate that there are probably 10-15 million cats in Illinois, 75 percent of which may be free ranging in rural areas. These numbers imply that currently accepted estimates of numbers of feline pets in this country may grossly underestimate the rural population. Perhaps the sketchy understanding of cat numbers in the United States, and how free-roaming cats affect natural ecosystems, in part explains the fact that only 1 out of every 10 county-level governments in this country attempts to control numbers of feline pets and their ownership.

Stresses Affect Illinois Trees

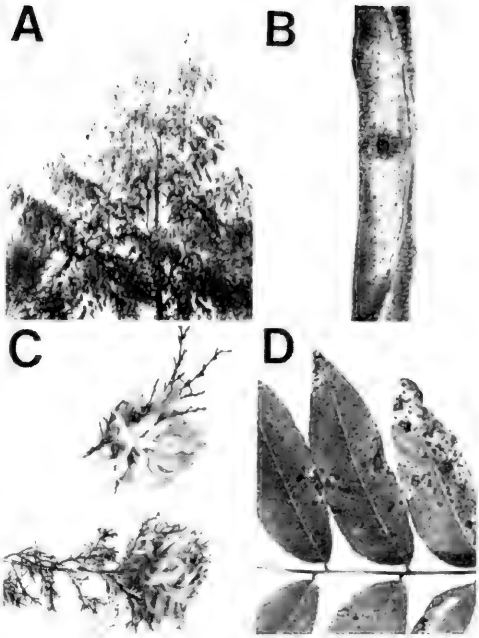
Before 1800, over 40 percent of Illinois

was covered by forest. Today only about 11 percent of its total acreage is forested, less than that of any state east of the Mississippi River. The conversion of wooded acreage to farmland, highways, and urban and industrial development has steadily reduced the forest resource base in Illinois to less than 3.5 million acres, compared with nearly 22 million acres of corn and soybeans. Even farm windbreak and hedgerow trees have disappeared in many areas, resulting in increased wind and water erosion of fertile topsoil. Because of their relative scarcity, the protection and preservation of trees in Illinois are vital issues for the state.

Many of the trees remaining in Illinois are suffering from stresses caused by biotic and abiotic factors, particularly urban trees along streets, parkways, and on private property. Biotic stresses are caused by insects and disease organisms, while abiotic stresses result from such things as drought, flooding, soil compaction, toxic herbicides and pollutants, and mechanical injuries. In many cases, trees are damaged by the combined effects of abiotic and biotic stresses. When trees are weakened by stress, they often become predisposed to attack by disease pathogens; consequently, outbreaks of tree diseases are common following a hard winter or after an extended drought. The severe drought of 1983 has had an obvious effect on corn and soybean yields, but it may be several years before the resulting damage to Illinois trees can be estimated.

Many abiotic and biotic stresses affect dozens of species and varieties of trees in Illinois. Although epidemic diseases, such as chestnut blight, oak wilt, and Dutch elm disease, have killed thousands of trees and are familiar to the public, many less well-known diseases cause significant damage each year. Keeping up to date on tree diseases requires a constantly changing and evolving program of basic and applied research. Plant pathologists in the Survey's Section of Botany and Plant Pathology have researched the biology and control of biotic and abiotic tree diseases for over 50 years.

Currently, three pathologists, Drs. E. B. Himelick, Dan Neely, and D. F. Schoeneweiss, each with 25 or more years of experience, are conducting research projects on tree diseases. These projects include studies on the biology of specific fungal pathogens, the evaluation of fungicides for disease control, root loss and root regeneration during and after transplanting, wound healing, the damaging effects of lawn herbicides on trees, the cause and prevention of tree declines, and basic research on the histology and biochemistry of tree resistance to disease and the breakdown of resistance under predisposing stress.



Examples of biotic stresses affecting Illinois trees. A. Verticillium wilt on green ash. B. Nectria canker on thornless honey locust. C. Sporulating cedar-apple rust galls on red cedar. D. Anthracnose lesions on black walnut.

There is increasing demand in Illinois for trees, not only for shade and ornamental value, but as noise and pollution filters, for reforestation of marginal lands, and for energy-yielding biomass. At the same time, trees are becoming increasingly subjected to stresses because of high costs for care and maintenance and the use of labor-saving transplanting equipment, which removes most of the root system when trees are moved. A continuing research effort will be required for the fore-

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seeable future to meet the issues raised by these changes.

New List of Publications Available

A long-awaited book, *Publications of the Illinois Natural History Survey, 1876-1983,* has recently been published and is now available. This list of Survey publications is far more extensive than earlier lists, and it appears in a completely different, more useable format.

This new book lists all publications of the Illinois Natural History Survey in the *Bulletin, Biological Notes,* and *Circular* series as well as in other Survey series no longer published. It also lists contributions of Survey staff members to serials and volumes published by other organizations and reprints of articles written by Survey staff and published in various journals after 1977.

The book is divided into five main sections, corresponding to the five scientific research sections of the Natural History Survey: Aquatic Biology, Botany and Plant Pathology, Economic Entomology, Faunistic Surveys and Insect Identification, and Wildlife Research. Within each section, publications are listed by author name in alphabetical order, and a standard bibliographic style is used in each listing.

Accompanying each listing is a symbol indicating whether the publication is available through the Natural History Survey, available only through the author, or out of print or not available from the Survey. Out-of-print Survey publications may be examined in the Illinois Natural History Survey Library.

Complete instructions for ordering publications are included. Single copies of Illinois Natural History Survey publications are furnished free to persons requesting them. Orders for more than one copy from educational institutions and similar organizations in Illinois and from others are filled whenever possible. However, because of publishing costs and limited supplies, the Survey attempts to limit distribution of its publications to persons and institutions that will make the best use of them.

To order a copy of *Publications of the Illinois Natural History Survey, 1876-1983,* send your request, including your name and complete address, to the Chief, Illinois Natural History Survey, 172 Natural Resources Building, 607 East Peabody Drive, Champaign, Illinois 61820.

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The osprey, an American hawk and an Illinois endangered species, carries fish as it flies over Rice Lake. The photograph was taken September 21, 1983 by Survey researcher Christopher Burnett.

LUMP Issues First Land Report

With the publication of *Illinois Land Report: Rice Lake Conservation Area,* the Illinois Lands Unsuitable for Mining Program (LUMP) has become a reality. As a result of recent state and federal legislation, this program establishes a process whereby Illinois citizens may petition the state to designate certain areas of land unsuitable for coal mining. Petitioned areas may be declared "unsuitable" if reclamation is not feasible, or if mining would conflict with existing land use plans, damage fragile or historic lands, reduce productivity of renewable resources, or increase natural hazards. The Illinois Department of Mines and Minerals (DMM) has the responsibility to determine whether the petitioners' allegations are justified and sufficient to prohibit or limit mining of the area in question.

The Illinois Department of Energy and Natural Resources (DENR) has two roles in this process: first, to maintain a natural resource information system and data base which will be available to the public to assist petitioners; and second, to prepare a land report on each petition area to provide DMM with the information needed to make its determination. These tasks will be greatly facilitated by a computerized "geographic information system" that is currently being installed at the Illinois Natural History Survey (INHS) to manage the vast amounts of data available on Illinois' natural and cultural resources. In addition to INHS, four other DENR divisions — the Geological and Water Surveys, the State Museum, and the Division of Energy and Environmental Affairs — contribute to the preparation of the Land Reports. The INHS is specifically responsible for evaluating biological and soil resources. Land Reports must address whether mining would have any of the undesirable effects, as well as contain a detailed statement on the potential resources of the area, the demand for coal, and the impact of designating an area unsuitable on the environment, the economy, and the supply of coal.

Land Reports must state available infor-

mation objectively, but will not recommend whether the petition should be granted or denied. Following publication of the report, public comments are accepted and a public hearing is held to provide citizens with opportunities to present evidence or testimony regarding the petition.

The Rice Lake Conservation Area, subject of the first Land Report, is located in Fulton County in west-central Illinois. The area covered in the Land Report encompasses 2,694 acres managed by the Illinois Department of Conservation primarily as migratory waterfowl habitat. The petition to prohibit mining was filed in December 1982 by the Save Rice Lake Area Association, Inc., a not-for-profit citizens' group. In terms of biological resources, the Rice Lake Land Report predicts that mining and subsequent reclamation would most likely have positive impacts on waterfowl and sport fishing but negative impacts on undisturbed plant communities, endangered species, nonconsumptive recreation, commercial fishing, and various ecosystem functions. For soil resources, compaction would likely be the major problem in restoring productivity should mining occur. Reclamation of wildlife habitat would be possible but would take several decades. These predictions regarding biological and soil resources will be weighed along with numerous other factors in the decision-making process. DMM is required to rule on the petition by 28 December 1983.

Dr. Philip W. Smith, author of *The Amphibians and Reptiles of Illinois*, and also one of the authors of the new publication, *An Annotated Bibliography of the Illinois Herpetological Literature, 1960-1980, and An Updated Checklist of Species of the State*.

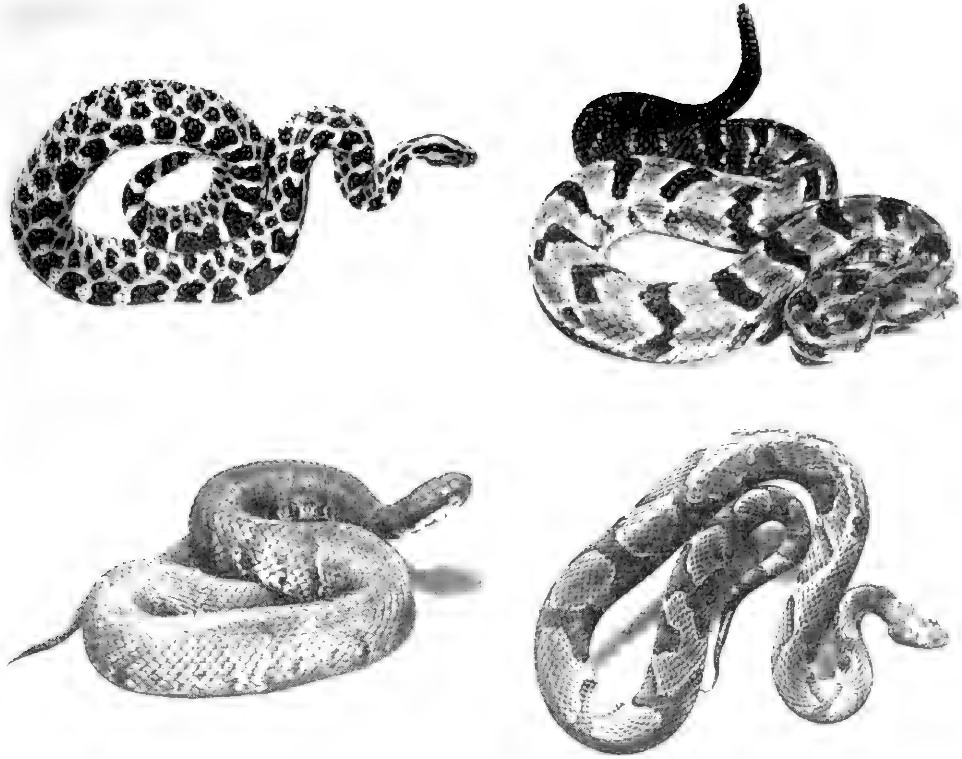
Amphibian and Reptile Bulletin Updated

In 1961, the Illinois Natural History Survey published a Bulletin entitled *The Amphibians and Reptiles of Illinois*. This extremely popular state report, written by Survey zoologist Philip W. Smith, has been reprinted without revision several times and has frequently served as a model for authors of books on the amphibian and reptile faunas of other states.

The appearance of the volume precipitated publication of more than 300 articles and books citing Illinois specimens or Illinois populations of amphibians and reptiles in the ensuing 20 years. Because of the immense amount of literature, biologists involved in preparing environmental impact reports have needed a summary of publications that have appeared in print since 1961.

Prompted by the environmentalists' need for recent data, Michael A. Morris (Southern Illinois University–Carbondale), Richard S. Funk (Ohio State University), and Philip W. Smith (Illinois Natural History Survey, retired) produced a new Bulletin entitled *An Annotated Bibliography of the Illinois Herpetological Literature, 1960-1980, and An Updated Checklist of Species of the State*.

Publications listed in the Annotated Bibliography are arranged alphabetically and numbered consecutively. Species listed in the Updated Checklist of Species are arranged phylogenetically and also numbered consecutively. The List of Titles and the Checklist are cross-referenced. Thus, a researcher can quickly ascertain which species are discussed in each of the publications listed and, after consulting the Checklist, he can determine which publications are pertinent for each of the Illinois species of amphibians and reptiles. The new Bulletin is thus a great time-saver for environmental biologists and provides them with a means for determining the



Four poisonous snakes of the state found chiefly in southern Illinois. They are (upper left) massasauga or swamp rattlesnake taken in Piatt County (Photo by former Survey photographer, W. E. Clark); (upper right) timber rattlesnake; and (lower left) cotton mouth or water moccasin, both taken in Jackson County, near Murphysboro (Photos by former Survey photographer, R. Hesselschwerdt); and (lower right) copperhead, taken in Randolph County, near Chester (Photo by former Survey photographer, Ray Hamm).

present environmental status for all Illinois species.

Single copies of the new publication are available upon request to: Chief, Illinois Natural History Survey, 607 East Peabody Drive, Champaign, Illinois 61820.

No Pesticides Found in Well Water Samples

Since almost half the population of the United States uses ground water from wells or springs as a source of drinking water, great concern has been expressed recently about the potential contamination of ground water by agricultural and industrial chemicals. Ground water is also important in irrigated crop production, and more importantly, it is an integral part of the hydrologic cycle of earth. When ground water sources, or aquifers, become contaminated by pathogenic microorganisms or toxic chemicals, there are only three courses of remedial action: forbid use of the aquifer and obtain alternate water supplies; attempt to rehabilitate it; or continue to use the water but treat it to remove the contaminants.

Contamination of ground water by agricultural chemicals has been noted in 13 states. When Wisconsin reported contamination of wells in the Central Sands region by pesticides that are registered for use in Illinois, Illinois Natural History Survey scientists decided to survey ground water quality for potential pesticide residues. Insecticide toxicologist Allan Felsot, in the Section of Economic Entomology, organized an interagency committee consisting of representatives from the State Water Survey, the Illinois Environmental Protection Agency, the Illinois Cooperative Extension Service, and the Illinois Departments of Public Health and Agriculture to study the problem.

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Owing to limited funds for nonroutine monitoring of pesticide contamination, the first action was to identify areas in Illinois where there was a high risk of ground water contamination. Since it is known that contamination is highly correlated with the downward leaching of chemicals in sandy soils, four such regions in Illinois were designated high risk. Areas of this nature that were sampled included Kankakee County, Mason County, Whiteside County, and Gallatin County. Stephenson County was included as a fifth region because of the occurrence of bedrock outcroppings that are also considered susceptible to ground water contamination.

Illinois Department of Agriculture workers collected five well water samples in each region during the month of June. Both deep and shallow wells were included in the sampling protocol. The samples were divided and sent to analytical laboratories at the Department of Public Health and INHS. Waters were analyzed for a wide variety of insecticides, herbicides, and fungicides with a detection limit of one part per billion (ppb = 1 microgram of pesticide per liter of water). No pesticides were detected at the five locations sampled in Illinois. Although the United States EPA has not set any no-observed-effect levels for pesticide residues in ground water, the detection limits in this study were equal to or less than the levels set for public water supplies.

Several chemical and field factors are known to facilitate the movement of pesticides into ground water supplies. Chemical factors include the pesticide characteristics of high water solubility and relatively little adsorption to soil surfaces. Field factors include well-drained or sandy soils with low organic matter content, high rainfall, and shallow, unconfined aquifers. Although these factors were applicable to several of the pesticides and wells tested, all waters were free of contamination.

Since remedial action for cleaning contaminated wells is very expensive and may not be feasible, the best method of ensuring clean ground water is prevention of contamination. This survey for potential pesticide contamination in Illinois ground water illustrates the cooperative interest among the various state agencies in maintaining good ground water quality in rural Illinois, and it is hoped the data generated will serve as a background for future monitoring studies.

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Chicago Area Deer Research Begun

A 3-year study of deer and deer-related problems in urban areas of Cook, Du Page, Kane, and Lake counties is being conducted by the Illinois Natural History Survey. It was initiated 1 July 1983. The investigation is being funded cooperatively by the U. S. Fish and Wildlife Service and the Illinois Conservation Department (DOC).

An extensive deer population has developed in the urban area of northeastern Illinois on local forest preserves, parks, and other suitable habitats. Deer herds sometimes reach a point where their numbers seemingly explode — a population bomb. The evidence indicates that deer numbers in the suburban Chicago area have reached critical proportions. Deer-motor vehicle accidents have increased alarmingly, with numerous injuries and damage to vehicles. Deer browsing on trees and shrubs have caused extensive damage in parks and forest preserves. Numerous complaints have been received from area residents about deer eating valuable ornamental plants and damaging gardens and crops. Deer have also become a problem on runways at O'Hare International Airport and have been removed from the airport on occasion.

Urban deer problems are not unique to Illinois; they exist in the urban areas of Minneapolis, Milwaukee, Cleveland, Detroit, and along the east coast. Experience in these localities has shown that deer management and control strategies must be tailored to local conditions and attitudes.

In rural areas, deer numbers are held within reasonable bounds by the annual removal of excess deer by hunters according to seasons and regulations carefully prescribed by the DOC staff. However, hunting is prohibited in many urban situations and alternative strategies must be sought. The urban deer problem is seen as being the sum of a series of local problems involving a number of different parks and forest preserves in the Chicago area.

Deer herd gathers in the kind of natural habitat they seek, but are sometimes unable to find (Photo by W. N. Wandell).

A basis of current, factual data is essential to solving wildlife-related problems. It is the responsibility of the Conservation Department to work with various local governmental agencies and with the owners of private property in trying to solve deer-related problems. The objective of the Survey in the deer study is to collect, analyze, and make such information available both to the DOC and to local units of government.

The urban deer research study project team is being supervised locally by Dr. Jim Witham, who is headquartered on land owned by the Cook County Forest Preserve District. He is being assisted by Jim Chelsvig, who has been transferred to the area

from Champaign. Dr. Glen C. Sanderson, head of the Survey's Section of Wildlife Research, is the principal investigator for the project. For several years, scientists of the Section of Wildlife Research have been studying management strategies for deer in the rural areas of Illinois.

The primary objectives of this urban deer study are to determine how many deer are in the four-county urban area, where they are, how fast their numbers are increasing, what their behavior and habitats are, whether they are healthy, how much damage they are causing, how many need to be removed for effective control, and relative costs of several possible methods of control.

Along with what the biologists refer to as the "population study," a management study will be initiated. The management study will evaluate methods of capturing deer on metropolitan parks and forest preserves and subsequently releasing them elsewhere in the state. In the past, Department of Conservation and Survey biologists have captured and transplanted relatively small numbers of deer, primarily for research and restocking purposes. However, capture and removal may not prove to be effective at a scale demanded by deer in the four-county urban region.

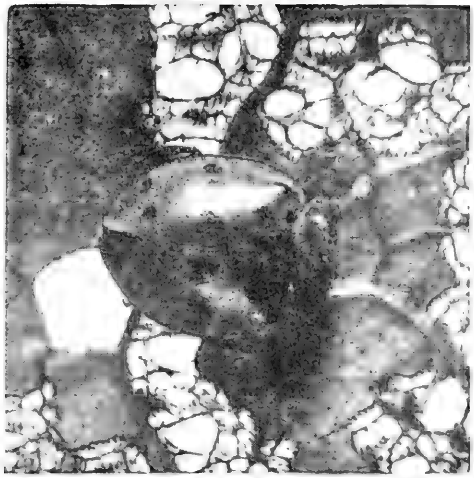
Information from DOC biologists and Survey studies indicates that the problem of deer in urban areas may relate, in part, to deer immigrating considerable distances from rural townships, as deer are highly mobile. Thus, Survey researchers have been asked to census deer throughout Cook, Kane, Lake, and Du Page counties to determine deer abundance, any damage problems, and the attitudes of landholders and homeowners toward possible control methods for deer in these four counties.

There is general agreement that a real problem exists and that it warrants immediate attention. It may be necessary to remove several hundred deer from the four-county area. A new crop of fawns comes each spring, and the surplus will probably need to be removed each year if effective population control is to be maintained.

Mexican Bean Beetle Population Is Monitored in Illinois

In Illinois, the Mexican bean beetle (*Epilachna varivestis*, Coleoptera: Coccinellidae) has historically been considered only as a pest of garden beans, and seldom, if ever, has it been found attacking soybeans. However, this beetle is a well-known pest of soybeans in several eastern coastal plain states, and recently it has become established as a serious soybean pest in areas of Ohio, Kentucky, Tennessee, and throughout most of Indiana. Yearly changes in the composition of the arthropod fauna on Illinois soybeans have been closely monitored by researchers in conjunction with the Illinois Cooperative Extension Service. Monitoring the incidence and trends in soybean-feeding arthropods is considered an important component of the state's Insect Pest Management (IPM) program. Any crop grown over such extensive areas as soybean in Illinois is highly vulnerable to exploitation by "new" pests resulting in serious economic impact.

Thus, the Mexican bean beetle has been the focus of attention in this respect for some years, due to the apparent expansion of its range westward in states neighboring Illinois. Although as early as 1971 the beetle was observed feeding on soybeans in a single field in east-central Illinois, there has never been an infestation of economic consequence. However, in 1981, Survey researchers Marcos Kogan and Charles Helm observed moderate populations of this insect in two counties bordering Indiana, and in 1982, the first instance of economically damaging populations of this beetle occurred in these same counties. Outbreaks were reported late in the season in both conventionally planted and late-planted or double-cropped beans as beetles massed in the few remaining green fields. Although nearly every field sampled contained a few adult beetles in the early spring of 1983, there have been no reports or observations of beetles on subsequent visits. However, perhaps most alarming was the report of a heavy population in a field nearly 50 miles due west of these original outbreaks.



Mexican bean beetle is shown on damaged soybean leaf (Photo by T. E. Benner).

Outbreaks such as this necessarily raise the question of changes in adaptation of the beetle to soybeans and/or changes in the susceptibility of Illinois soybean plants to the pest. Both hypotheses are currently being tested in the laboratory. Presently there appears to be little evidence that these apparent changes in feeding preference of Illinois beetles are due to genetic changes in the beetles themselves. There is some evidence that these changes are related to the quality of the plant; however, both of these hypotheses require considerable additional testing.

Continuous monitoring of not only beetle populations, but also agricultural practices and ecological conditions, in addition to laboratory studies, will provide a much better understanding of the mechanisms involved in the expansion of this beetle's range and host preference.

Urban Pesticide Usage by Arborists

Seventy-four percent of the population in the United States lives in urban areas surrounded by 200 million trees and 800 million shrubs. The use of pesticides to keep these plants free of insect pests and diseases is increasing. Advancement in pest control procedures is years behind the current developments in agricultural fields and urban Integrated Pest Management (IPM) is in its infancy. One of the major users of pesticides in urban areas is the arborist. Commercial arboriculture is a 1 billion dollar per-year industry involving pruning (37 percent), spraying (18 percent), and tree removal (16 percent). No data assessing the use of pesticides by arborists are available.

The research objectives by Dan Neely and Eugene Himelick, plant pathologists, were to determine 1) the pests to be controlled, 2) the pesticides used to control them, 3) the host plants being treated, 4) the quantity and cost of pesticides applied, 5) the time of application, and 6) the equipment being used. The relative economic importance of pesticide application to the total value of services offered by commercial arborists was also sought.

The objectives were fulfilled through questionnaires and personal interviews. Separate questionnaires were prepared for the commercial and the municipal arborists to present their differing interests, methods, and goals. Questionnaires were mailed to 529 tree experts with licenses to practice commercial arboriculture in Illinois.

Of the 529 questionnaires mailed to licensed arborists, 156 were returned. Of the 40 questionnaires mailed to arborists that are employed by municipalities, 20 were returned. These, plus the 16 licensed arborists employed by municipalities, composed the data sample for municipal arborists.

The results can be summarized as follows. Most of the arboriculture firms perform tree maintenance services other than tree pest control. In 29 percent of the firms, the pest control income is less than \$7,000 annually. In 63 percent of the firms, this income is substantial, from \$8,000 to \$150,000. The remaining 8 percent is over \$150,000. Most of the pest control services are performed for homeowners on private grounds. The training of employees who operate sprayers for arborists is primarily on the job. Applying the pesticide at the proper time seems to be the most difficult of the problems related to tree and shrub pest control.

The insecticide usage by Illinois arborists is substantially greater than the fungicide

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usage: thirteen times as many applications of insecticides alone as fungicides alone, and two times as many insecticides alone as combinations of insecticides and fungicides. The disease most important to commercial arborists is scab, followed by rust and anthracnose. The most important insect problem is scale, followed by aphids and bagworms. The 20 arborists who responded on the municipal arborist survey form confirmed the Neely and Himelick opinion that Dutch elm disease has been the major problem for Illinois cities.

The size of the municipal budgets to be used at the discretion of the muncipal arborists for pest control activities is small. Three arborists state they have no funds specifically to be used for tree-pest activities; another three of 12 responding to this question had over $20,000 in the 1982 budget. The average for the 12 cities was $15,000 for protection of city trees. Application of sprays at the proper time is rated the most difficult problem for municipal arborists; diagnosis of the problem is rated the second most difficult. The apparent need to apply substantially more insecticides than fungicides was similar in both groups.

An effort was made to personally interview arborists with a range in interests and size of operation. An effort was also made to select arborists distributed geographically throughout Illinois. The tree hosts with eight or more insect-pest problems include crabapple, elm, honeylocust, maple, oak, and fruit trees. The tree hosts with three or more disease problems are crabapple, hawthorn, oak, and fruit trees. June was the month of greatest activity for insecticide application with almost 1 million treatments to trees. April and May were the only months with extensive treatments with fungicides. The dollar value of pesticides purchased by licensed commercial arborists in Illinois in 1982 was substantial, averaging $8,500. Of this, 15 percent was for fungicides and 85 percent was for insecticides. According to the calculations of Himelick and Neely, over 2 million dollars were spent by licensed arborists in Illinois for pesticides in 1982.

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Monographic Study of *Torula*

The genus *Torula* was established by Persoon in 1795 for fungi with dark, bead-like, one-celled, asexual spores (conidia). Because of this vague generic concept, a large number of unrelated organisms have been grouped in this genus which presently contains nearly 600 species. Included among these fungi are pathogens of man and animals which cause localized swollen lesions on the hands and feet (*Torula jeanselmei*) as a result of subcutaneous infections or which cause pulmonary nodules or systemic infections of the lungs (*Torula neoformans*). The identifications of many medically important fungal pathogens are difficult because of incomplete descriptions with poor or no illustrations. This, in turn, affects diagnosis and treatment. *Torula* fungi are commonly encountered in soil, water, air, and on decaying and living substrates. They represent an important segment of any mycological flora, and studies that will define the generic and species concept in *Torula* are necessary for a better understanding of the species and their accurate identification by mycologists and persons in allied professions.

Presently, Lee Crane, Survey mycologist, is attempting to establish the range of variability in *Torula herbarum*, the species which delimits the group (genus). In this study, the classification of the genus will be based on developmental and morpho-

Photomicrograph of *Torula herbarum* illustrating the heavily melanized, coronate, conidiogenous cells and chains of conidia. X 2,000 (Photomicrograph by Lee Crane).

logical characters. In *T. herbarum* and other bonified species, the cell that produces the asexual spores (conidia) appears to be the diagnostic character. It is crown-like and heavily colored at the base. The conidia are ornamented with warts, and the spore size and number of cells per conidium are constant within a range for each species. All recognized species of *Torula* appear to fall within two basic groups: those with the conidia borne singly and those with conidia in chains. The biological constancy of these characters will be studied. A key and detailed descriptions with illustrations will be provided for the accepted *Torula* species and any new species. Information for each species on typification, synonomy, geographical distribution, and host or substrate range will be provided. The monograph will include an index of all names published in *Torula* along with the source of publication, history, and present disposition.

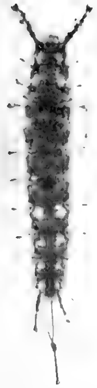
This study will provide basic biological information on a genus about which there has been much confusion since its establishment and will serve as a reference manual to the early mycological and medical literature where species named as *Torula* are cited.

Effect of Stalk Borer Injury on Corn Yield

Female moths of the stalk borer, *Papaipema nebris,* oviposit primarily on grasses in fence rows, contour strips, grass waterways, or in weedy fields during the late summer and early fall. After the eggs hatch the following spring, the larvae begin feeding on grasses but move to larger plants as they outgrow their original hosts. Corn may serve as this larger plant if planted in or near infested grasses. Stalk borer larvae injure corn plants in two ways: by burrowing into the base of the plant and tunneling up through the center of the stalk or by entering the plant through the whorl and tunneling down. Both types of attack may result in misshapen or stunted plants and severely damaged plants may die.

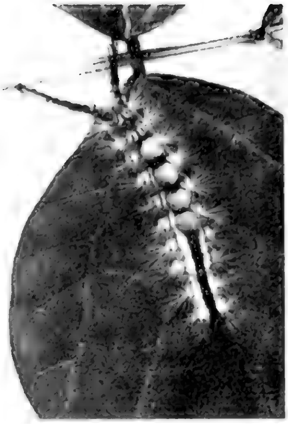
The recent increased use of conservation tillage practices by field corn producers in the central corn belt has led to a greater incidence of stalk borer problems. In particular, serious infestations can occur throughout entire fields where no-till is practiced if these fields harbor stalk borer eggs and larvae before spring planting. After herbicides are applied to kill existing weeds, the stalk borer larvae are forced to attack the corn seedlings, the only remaining food source. For conventionally tilled (fall-plowed, spring-disked) corn fields, stalk borer damage is usually restricted to the first four to eight rows of corn that are adjacent to field margins, contour strips, or grass waterways containing stalk borer infested grasses.

Eli Levine, a Survey entomologist, assessed the impact of natural populations of stalk borer larvae on the ability of corn plants to recover after injury was inflicted at different plant growth stages (leaf stages two through eight). The study was conducted in three no-till fields and three conventionally tilled or reduced tilled (fall chisel-plowed) fields over the course of 3 years (1980 to 1982). He found that yield losses resulting from injury by larvae were due to both the reduction in the number of plants producing ears and the reduction in grain weight per ear. In general, seedlings injured earlier in development produced fewer harvestable ears (plants producing ears that contained a kernel weight of 30 or more grams at 15.5 percent moisture were considered harvestable) and less grain than plants injured later in development. Injured plants also tended to sucker (grow additional shoots) more than uninjured plants. He also found that of the injured plants that did not set harvestable ears, over 58 percent survived to harvest time. These nonproductive plants probably competed with the uninjured plants for sunlight, moisture, and soil nutrients until harvest. Levine did not find new damage in plants beyond the eight-leaf stage. He also found that damage to corn in plots adjacent to field margins containing stalk borer-infested grasses varied by row with the row immediately bordering the field margin generally sus-



Inflated caterpillar of *Dasychira vagans* (Barnes & McDunnough), collected in 1898 and first illustrated in a 1913 publication on tussock moths (Photo by G. L. Godfrey).

Caterpillar of *Dasychira basiflava* (Packard) on white oak, Mississippi Palisades State Park, Carroll County, Illinois, June 1983 (Photo by G. L. Godfrey).



White-marked tussock moth caterpillar, *Orgyia leucostigma* (J. E. Smith), normally feeds on deciduous trees and shrubs, rarely found on soybeans (Photo by G. L. Godfrey).

taining the most damage. The results of this study should be useful in the development of damage thresholds for this pest. When this information is generated, corn producers will have a better idea when chemical control is economically justified.

Dasychira vagans: Octogenarian Visitor

A well-traveled, 86-year-old tussock moth caterpillar specimen (first picture), *Dasychira vagans* (Barnes and McDunnough), that formerly resided in Illinois visited the Survey briefly in 1983. The caterpillar was collected in the summer of 1898 near Meach Lake, Quebec, Canada, was inflated for preservation, and spent the next 30 years in the collection of the late Dr. Williams Barnes of Decatur. In the early 1930's, it, along with the rest of the large Barnes Collection, was sold to the US Department of Agriculture which transferred its custody to the United States National Museum of Natural History (Smithsonian Institution), Washington, D.C. Its temporary return to Illinois was arranged by Associate Insect Taxonomist George L. Godfrey, who spotted it in the National Museum and recognized it as the specimen that had been illustrated in a 1913 publication on the Lymantriidae (tussock moths). The clue was a misplaced, black seta (hair) on the right side of the body about one-third of the way from the head.

Godfrey normally does not check caterpillars to see if their hairs (setae) are in place before photographing them, but in this case was involved in a study of the North American tussock moth caterpillars and was searching for museum specimens to complement those that he had reared (middle picture) in order to complete the project.

The lymantriid study that was recently completed is Godfrey's third contribution on caterpillars to a national project about immature North American insects that F. W. Stehr, Michigan State University, is coordinating. The lymantriids include several major and minor pests of trees and shrubs. Examples from Illinois include the notorious gypsy moth caterpillar, *Lymantria dispar* (Linnaeus), and the lesser known, white-marked tussock moth caterpillar, *Orgyia leucostigma* (J. E. Smith) (third picture). Presented in the study are photographs of representative caterpillars of all the North American lymantriid genera, a synthesis of the known host plants, phenological and distributional information, and the basic diagnostic characters for identifying the caterpillars.

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Rural Cats — A Look into the Future

A recent article in the *Natural History Survey Reports* described a free-ranging rural cat population in central Illinois. What are likely trends for future numbers of cats in this state? Wildlife Ecologist Richard E. Warner estimates that currently there are approximately 5.5 million cats in Illinois; further, if national trends continue for a growing percentage of households with cats and more cats per household, there could be up to 10-15 million cats in this state by the year 2000.

Because free-ranging cats prey upon wild animals, a potential change in densities of felines in rural areas is an important consideration. There are two shifts occurring in the human population that suggest a high probability of greater numbers of rural cats in the future. First, there have been about 850 new hobby farms (less than 50 acres) established each year in Illinois since the late 1960's. Secondly, rural communities are expected to sustain a growth in numbers of households. For example, 75 percent of the small towns in the 34 southernmost counties of Illinois are presently growing. Hence, as people show a growing preference for rural living, there is little doubt that feline pets will appear in growing numbers on the rural landscape.

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Endangered and Threatened Species in Illinois

In his fervor to improve his lifestyle and conquer all natural barriers, Man has exploited and changed most of the native habitats of the earth. As one result, the natural process of extinction has been drastically altered and significantly increased. Since the early 1600's, over 500 species of native plants and animals have become extinct. Many others have been brought to or near the edge of extinction and are considered, respectively, endangered or threatened.

The official list of endangered and threatened plants for Illinois contains 363 species. The official list of such vertebrates for Illinois includes 13 fish, 11 amphibians and reptiles, 40 birds, and eight mammals. Of these, one fish, four birds, and two mammals also are listed as federally endangered. While no official state list of endangered or threatened clams presently exists, four of the 23 federally endangered clam species are known to occur in Illinois.

Xanthocephalus xanthocephalus, yellow-headed blackbird, in *Typha*, cattail marsh (Drawing by Ms. Patti Katusic).

In Illinois, endangered species are defined as those naturally reproducing native species likely to be extirpated from this state in the near future. Threatened species are those likely to become endangered in the near future. Most of the native species of plants and animals existing in Illinois today are surviving in marginal or detached habitats. Of principal concern is the protection of critical habitat necessary for the successful reproduction of endangered and threatened species within the state.

The Illinois Department of Transportation (IDOT), Bureau of Location and Environment, is required by the Endangered Species Act of 1973, as amended, to conduct biological inventories for the purpose of identifying federally listed endangered and threatened species likely to be affected by its highway construction projects. Plant and animal species listed as endangered or threatened in Illinois by the Illinois Endangered Species Protection Board are considered in a similar fashion. The Illinois Natural History Survey (INHS) in cooperation with IDOT, has conducted such inventories since 1981. Survey staff members in the Sections of Faunistic Surveys and Insect Identification and Botany and Plant Pathology primarily have been responsible for these inventories. Scientific staff members include Project Coordi-

nator W. U. Brigham; Project Manager, M. J. Wetzel; Botanists, K. R. Robertson, R. C. Moran, and W. McKnight; and Zoologists, L. M. Page, L. Suloway, R. Grosser, M. E. Retzer, J. Kasprowicz, M. Morris, and S. L. Sandberg.

The objectives of these studies are (1) to locate all existing populations of the endangered and threatened plants and animals in the study area; (2) to establish from literature, field observation, and consultation with experts, the boundaries and abundance of each population; (3) to document the known life history and the ecology and environmental requirements of the species; and (4) to assess the potential impact of the proposed project on these populations within their specific habitats.

The collective efforts of the Natural Land Institute, Illinois Natural Areas Inventory, Illinois Department of Conservation, Illinois Endangered Species Protection Board, the Audubon Society, the US Fish and Wildlife Service, Morton Arboretum, The Nature Conservancy, and many other public and private groups have provided the information needed to assess the status of native species in our state. While the principal objective of these inventories is to protect critical habitat used by Illinois endangered and threatened species from reduction or elimination from highway construction, the information assembled also can be used to address the special problems of these species. Preservation of land, reintroduction of native species, management of natural and artificial habitat, breeding programs, and life history studies are all options available for managing endangered and threatened species once critical habitat has been identified. Their current status as "endangered" and "threatened" species is the result of the expansion of the human species. Thus, it is appropriate that we make the effort to assure their survival. Present and future land ethic in Illinois must give priority to its natural resources.

Fungal Pathogens of Insects in Alfalfa

Alfalfa is the world's most valuable cultivated forage crop. In the United States, it is surpassed in total acreage only by corn, soybeans, and wheat. This forage crop is recognized as providing the best food value for all classes of livestock as it produces about two times as much digestible protein as clover and four times as much as timothy-clover hay or corn silage. In addition, alfalfa adds nitrogen to the soil, improves water filtration, and improves soil structure.

Alfalfa is grown as a perennial and as such is a unique agroecosystem. It is relatively long lasting (3-5 years) but is harvested every 4-6 weeks which creates short-term cycles. Because of its relatively low per-acre economic value, alfalfa can tolerate a level of insect pest presence which might not be allowable in another crop. Therefore, alfalfa is ideal for the application of integrated pest management techniques.

Of the many insects which live in alfalfa, the alfalfa weevil (*Hypera postica*) and the potato leafhopper (*Empoasca fabae*) are considered the primary pests. Alfalfa weevil larvae occur in the spring causing serious economic damage by defoliating the plant. The adult alfalfa weevils disperse to wooded areas near the alfalfa field to remain dormant through the hot summer months. In the fall, the adults migrate back to the field and begin laying eggs. The potato leafhopper, on the other hand, does not overwinter in Illinois. This small green insect migrates from the gulf coast states each spring and becomes a pest during the second and third alfalfa growth periods in midsummer. It causes damage by sucking plant sap and blocking conductive tissues. This feeding causes leaf tips to yellow and die which leads to a reduction in total protein produced.

Both of these insects have fungal pathogens which attack them. The alfalfa weevil is attacked by *Erynia phytonomi*. This pathogen was initially discovered in 1974 in Ontario, Canada, and since then has spread rapidly throughout the United States. At times, disease incidence may range as high as 100 percent in certain populations of weevils given ideal microclimatic conditions. When this disease occurs early enough in the weevil's life

cycle, economic damage is averted, thus reducing the need for an insecticide application. Presently, Survey entomologists are working to determine what factors are important in the initiation and spread of naturally occurring epizootics and how this disease affects other biological control agents (e.g., parasites and predators) of the alfalfa weevil.

Erynia radicans is a fungal pathogen which infects the potato leafhopper. In 1982, Survey entomologists received a leafhopper with this disease from researchers in Wisconsin. This generated an interest in the potential use of this pathogen as a biological control agent. A literature survey indicated that very little research has been done with this pathogen, but several reports indicated that at times potato leafhopper populations had been severely affected by *E. radicans*. A survey of Illinois in 1983 failed to locate any leafhopper populations which were affected by any pathogens. However, a trip to Wisconsin yielded several leafhoppers infected with *E. radicans*. Presently, researchers are working with these isolates to determine: (1) basic transmission and epidemiological parameters involved with this pathogen-host system; (2) host range of *E. radicans;* (3) mode of overwintering; and (4) why this pathogen was not found in Illinois in 1983.

Once the basic biology of these two pathogens is understood, integrated pest management tactics may be developed which would facilitate their use as biological control agents.

Abandoned Mines in Northern Illinois

Illinois has an abundance of coal with approximately 65 percent of the state overlying coal-bearing strata. Ever since the first mine opened in 1810, Illinois has been an important provider of this resource. However, until 1962 little was done to protect the environment. During that year, the first surface mine reclamation law became effective in Illinois, and in 1972 the Pollution Control Board issued regulations concerning water quality from deep- and surface-mining operations. Consequently, a large number of sites, abandoned prior to the 1960's, were never reclaimed and many still pose environmental hazards.

During 1982, Claus Grunwald and Diane Szafoni of the Illinois Natural History Survey were granted a contract from the Abandoned Mined Lands Reclamation Council to study revegetation possibilities of the abandoned mines of the Longwall District in northern Illinois. Louis Iverson, also a Survey staff member, has since joined the research group. Deep mines in the Longwall District were in operation from 1875 to 1930, and the area presently contains over 100 refuse piles, generally lying within 20 miles of the Illinois River between Morris (Grundy County) and Peoria (Peoria County), Illinois.

Typical abandoned mine site in northern Illinois, near Standard, showing severe erosion and lack of vegetative cover.

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Revegetation of most of these mine sites by natural processes, even after 50 or more years, has been negligible and thus causes a number of environmental problems, including sedimentation and decreased water quality of streams. The natural establishment of vegetation has not occurred because of generally very steep topography, lack of moisture, relatively high soil acidity, and the exposure to poor soil texture and fertility conditions.

The mine waste represented material removed from directly above and below the No. 2 coal seam during the Longwall mining process. A complete inventory of plants growing on the poorly revegetated pile was conducted during the summer and fall of 1982 and the early summer of 1983. A total of 40 species of vascular plants was found, with most of the vegetation confined to the lower slopes. Even though the mine has been closed for many years, most species represent early successional stages. Measurements of water potentials and temperatures of the gob material revealed excessively harsh growing conditions, especially on southern slopes. The combination of steep slope and poor moisture retention of the gob material makes water availability an important limiting factor restricting plant growth.

Chemical analyses of the mine gob materials have revealed additional potential problems. Although the pH ranges between 3.2 and 4.0, lime requirements to correct this problem were reasonably low. Nitrogen, phosphorus, and potassium were found to be extremely deficient, and fertilizer would be required for proper plant growth. The gob material was also fairly high in aluminum and iron which could present a toxicity problem at low pH; however, adjustment of pH through liming should correct any toxic effect.

To further explain some of the nutrient problems, a greenhouse experiment has been devised which eliminated water as a limiting factor. The soil modifications that were tested were lime, fertilizer, lime plus fertilizer, and sewage sludge. The total biomass accumulation plus the shoot: root ratios were monitored for three grasses (tall fescue var. 'Kentucky 31', little bluestem, and side-oats grama) and two legumes (black locust and crownvetch). With all species, except black locust, the addition of sewage sludge produced the greatest production of plant biomass. Black locust responded best to fertilizing. In general, the fertilizer treatment ranked second and the lime plus fertilizer third, followed by the lime treatment and the sand treatment. The poor responses to sand or lime treatments underscore the nutrient deficiency problems; gob texture or pH problems are secondary in importance. It would appear from these results that the use of sewage sludge, both for its water-retention and nutritive qualities, should be pursued further for the revegetation of northern Illinois mine gob piles when economically and environmentally acceptable.

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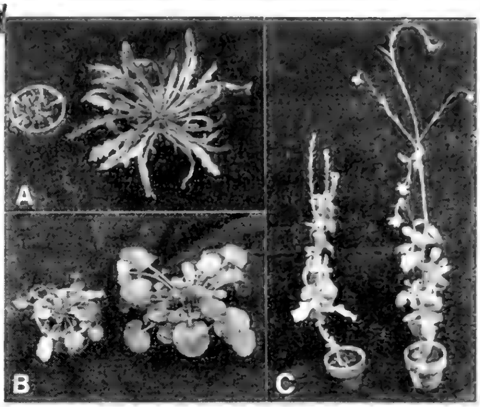
Newly Discovered Plant Hosts of *Spiroplasma citri*



Chlorosis and stunting resulting from *S. citri* infection in (A) shepherd's purse, (B) yellow rocket, and (C) wild mustard. In A-C, the plants on the left were exposed to infected *C. tenellus* and the plants on the right to control leafhoppers.

Brittle root has been the most destructive disease of Illinois horseradish since it was first reported in 1936. In 1981, plant pathologists and entomologists at the University of Illinois and the Illinois Natural History Survey, in cooperation with researchers at the University of California at Davis, provided a key to understanding brittle root with their reports that the causal agent of this disease is the helical bacteria-like organism *Spiroplasma citri*. The Illinois team further demonstrated that the beet leafhopper (*Circulifer tenellus*) can transmit *S. citri* to and from horseradish, and that the aster leafhopper (*Macrosteles fascifrons*) is also an experimental vector of this pathogen.

Many questions remain concerning the epidemiology of brittle root in Illinois. The disease is present in horseradish at a very low level almost every year and has occurred at irregular intervals in epidemic proportions with heavy crop losses. Do leafhopper vectors bring *S. citri* into the state from the western United States, where *S. citri* causes a major disease of citrus? Or are there plant hosts, especially weeds, serving as reservoirs of *S. citri* in Illinois or elsewhere in the Midwest from which leafhoppers could transmit this pathogen to horseradish?

Recently, Entomologists Karen O'Hayer, Gerald Schultz, and Catherine Eastman, and Plant Pathologist Jacqueline Fletcher conducted a study to explore the feasibility of the local weed reservoir hypothesis. *S. citri* has a wide experimental host range which includes several wild brassicaceous plants, and field-collected weed species have been found to harbor spiroplasmas in California and Arizona. No work had been done, however, to determine the susceptibility of wild plant species to midwestern isolates of *S. citri*. O'Hayer and her colleagues set out to determine if three brassicaceous weeds common in the Midwest — yellow rocket (*Barbarea vulgaris*), wild mustard (*Brassica kaber*), and shepherd's purse (*Capsella bursa-pastoris*) — could serve as sources for transmission of an Illinois isolate of *S. citri* to horseradish.

First, beet leafhoppers injected with suspensions of cultured *S. citri* were used to inoculate yellow rocket, wild mustard, and shepherd's purse test plants to determine their susceptibility to *S. citri* infections. Injected leafhoppers and non-injected controls were held on sugar beet plants for 22 days to allow time for spiroplasma multiplication within the injected insects and infection of their salivary glands. Then they were caged in groups of 10 on five

seed-grown test plants of each weed species. After 7 days, surviving insects were transferred to fresh test plants of the same species for another 7 days. Chlorosis and stunting of young leaves characteristic of *S. citri* infection developed in 4 of 10 yellow rocket and shepherd's purse test plants and in six of nine wild mustard. Enzyme-linked immunosorbent assay (ELISA), a diagnostic test which uses serum containing antibodies generated in response to a specific pathogen, confirmed the *S. citri* infections. All test plants caged with control leafhoppers remained free of symptoms and were negative by ELISA.

To determine if beet leafhoppers could acquire and subsequently transmit *S. citri* from these infected weeds, leafhopper nymphs were confined in separate cages with four source plants or four healthy plants of each weed species for 7 days and were held on sugar beet plants for another 26 days. Insects fed on source plant species were then caged in groups of 10 on five test plants of the same species and on five horseradish test plants. After 7 days, surviving insects were transferred to fresh plants of the same species for another 7 days. Leafhoppers previously confined with either infected yellow rocket or shepherd's purse plants transmitted *S. citri* to all 10 yellow rocket or shepherd's purse test plants, respectively, and to all 10 horseradish test plants. Leafhoppers confined with infected wild mustard transmitted the spiroplasma to all 10 wild mustard and to 9 of 10 horseradish test plants. Plants were diagnosed as infected by symptomatology and confirmed by ELISA. All test plants caged with leafhoppers fed previously on healthy weeds remained free of symptoms and were negative by ELISA.

Preliminary searches for spiroplasma-infected weeds near horseradish fields in Illinois have been unsuccessful, but intensive studies have yet to be conducted. The report that yellow rocket, wild mustard, and shepherd's purse can be infected by *S. citri* expands the host range of this spiroplasma and is the first study to use a midwestern isolate. The demonstration that these weed species can serve as sources for transmission of *S. citri* to horseradish is an encouraging first step in long-term research to determine the possible involvement of local or regional wild plant populations in the epidemiology of brittle root disease.

Prairie Chicken Management — Cycles, Densities, and Thresholds

Illinois' long-term data base on prairie chickens is matched by few other states within the range of the species. Yet, adequate answers to some basic questions are still needed. For example, is there a minimum population size below which demographic factors, environmental variations, natural catastrophes, or genetic factors such as inbreeding, may depress a population to extinction? Grouse such as prairie chickens sometimes show cyclic fluctuations in their numbers at intervals of about 10 years. Are prairie chickens in Illinois cyclic? If so, how much variation in population densities can be expected between cyclic lows and highs? Grassland habitat suitable for successful nesting has long been recognized as the critical factor limiting the abundance of prairie chickens in Illinois.

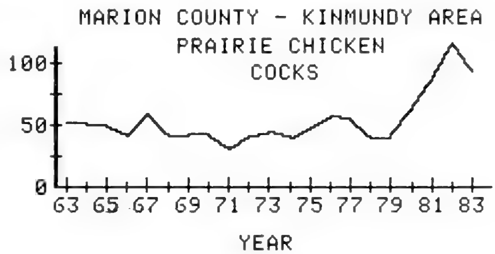
But how much grassy nest cover is required for the long-term preservation of the species? Should nest cover be a single, large block? Or, if a scatter pattern of sanctuaries is best, there are questions of number, size, shape, and dispersion to answer. These topics were addressed by Illinois Natural History Survey Wildlife Ecologist Ron Westemeier at a recent meeting of the National Prairie Grouse Technical Council in Emporia, Kansas.

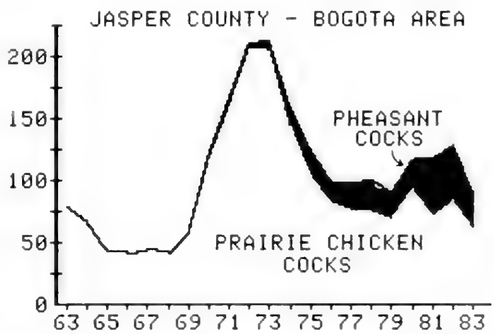
Some geneticists believe that, in general, a population must not fall below 50 individuals, yet others indicate that for those species like the prairie chicken that perform their courtship and mating activities on special display grounds or areas, the minimum population size may be more like 150-200 individuals. The prairie chicken flock near Bogota in Jasper County approached the supposed threshold of 50 birds in the mid-1960's, but recovered dramatically to some 400 birds in 1972-1973. Currently, the Bogota flock is down to 100-120 birds, probably due principally

Prairie chickens on booming ground of their natural habitat. Cocks are larger and more ornate birds than the hens.

to competition by pheasants. The prairie chicken flock near Kinmundy in Marion County was down to about 50 birds in 1971, but by 1982 this flock probably exceeded 200 individuals. These responses provide some basis for speculating that a minimum population size for prairie chickens may be somewhat below 50 birds.

A basic phenomenon to be considered in studies of the dynamics of grouse populations is the tendency for their numbers to cycle at intervals of about 10 years. The prairie chicken population in Jasper County showed (1) probable highs in 1962-1963, (2) definite highs in 1972-1973, and (3) if pheasant counts are added, a high was also evident for 1982. Pheasants were added to the prairie chicken counts because of their overlap in ecological requirements. Both species are concentrated on the sanctuaries. In Marion County, although relative stability was maintained from 1963 through 1979, a definite high in 1982 was in synchrony with the combined prairie chicken-pheasant population at Bogota and population highs in Wisconsin and Minnesota. Thus, cycles may indeed be natural phenomena to be considered. Over a decade, abundance can be expected for several years — typically in





Two graphs show the fluctuations in the counts of prairie chicken and pheasant cocks only on two separate sanctuaries. Counts for cocks and hens are usually about 50-50.

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years ending in 1, 2, or 3 — but relative scarcity must also be expected about half the time — typically in years ending with 6, 7, or 8.

Currently, two scatter-patterns of sanctuaries totaling 1,920 acres (14 separate tracts) in Jasper and Marion counties are managed cooperatively by the Survey, the Illinois Department of Conservation, and The Nature Conservancy. Although sanctuary acquisition began in 1962, a good test of the density of prairie chickens that can be maintained through so-called cyclic lows did not occur until the 1976-1978 period. By that time, a stabilized program of sanctuary management was underway in both counties. The two populations did not show simultaneously clear troughs in 1976-1978, but their numbers were relatively low. The prairie chicken densities then were essentially identical in both counties — 70 cocks per square mile of nest cover (on sanctuaries). On average, densities of 100 prairie chicken cocks per square mile of nest cover appear realistic for Illinois (perhaps the highest in the range of the species). During cyclic highs, the density may be 2 or 3 times that of the density at cyclic lows.

The data on cycles, densities, and possible thresholds suggest an acreage goal of 1,500 acres in each of two areas of Illinois, of which about 75 percent might realistically provide quality nest cover on an annual basis. Such an acreage could be expected to support 200 prairie chickens during cyclic lows, an average of 300 birds, and up to 600 grouse at cyclic highs. These population sizes would range from 4 to 12 times the supposed extinction threshold of 50 birds and provide a measure of safety against such factors as pheasant competition, oil development activity, heavy predation of nests on the sanctuaries, and increasingly intensive land use around the sanctuaries.

Thus, an additional 1,000 acres of sanctuaries should be added to the present systems. Because of the success of Illinois' scatter patterns and the historically poor "track record" of single, large refuges in Illinois and in other states, new sanctuaries should also be scattered. Sanctuaries may range from 80 to 160 acres or more in size, and not be more than about 1 mile apart. Better management of existing sanctuaries is also a critical need. Hopefully, Illinois' new nongame wildlife check-off program will provide funding to help meet management needs of the prairie boomer and other components of our prairie ecosystem.

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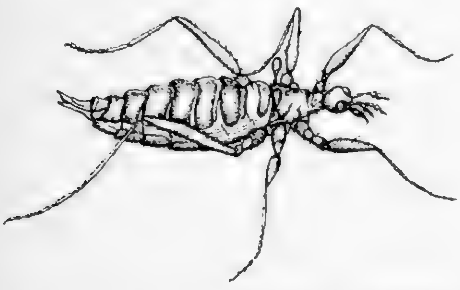
It's a Snow Fly!

In winter few people expect to see insects crawling about on the snow, but Survey biologists, John Unzicker and Allison Brigham, are studying the biology of a wingless fly that does just that. A member of the forest litter community in Illinois, this small (3-4 mm long) insect, *Chionea stoneana,* is active on the snow at temperatures as low as 10°F (−12°C).

Since invertebrate animals are cold-blooded (poikilotherms), keeping active during winter is important to the survival of insects like *Chionea.* This dark-colored fly can be seen walking on snow in woodlands from mid-November through early February. *Chionea* belongs to an arthropod community active in the forest litter layer under winter's snowy blanket that includes other animals such as beetles, spiders, mites, gall-making wasps, scorpionflies, centipedes, millipedes, and springtails.

The genus *Chionea* in North America occurs in relatively dry oak-hickory forests, northern beech-maple associations, and the mixed deciduous and evergreen forests of eastern Canada. In the western mountains, *Chionea* may be found from the lower dry forests of ponderosa pine up through the zone of lodgepole pine, and into the high alpine forests of spruce and fir.



The small (3-4 mm long) insect, *Chionea stoneana,* as drawn by Mary Beth Kidd.

Adult *Chionea* appear during the cold months of the year, mate, disperse, with females laying eggs in the forest litter or on the soil surface beneath the litter. The eggs apparently take 1 or more months to hatch. The wingless condition of these flies is utilized in an interesting way. Gravid females hold eggs in the thorax as well as in the abdomen. Since these insects lack wings, the thorax is not packed with large flight muscles. Therefore, the space in the thorax can be used as additional storage space for eggs. The larvae of *Chionea stoneana* grow throughout the warm months of the year, with pupation occurring at the end of the summer or in early autumn. Adult emergence begins in mid-November, completing the cycle.

Little else is known about the activities of this fly in the litter-soil surface layer because it blends in with the drab colors of the twigs, leaves, and bark that constitute most of the plant biomass of this layer. The snow layer on the soil protects the animals living in the litter layer and on the soil surface. A 6-inch layer of snow will keep the soil surface up to 15°F warmer than the air above the snow.

As the snow melts exposing the bases of trees and other woody vegetation during "warm spells," openings or channels occur in the snow through which animals can escape to disperse throughout the woodland. *Chionea* have been seen to walk in a straight line as far as 100 feet on the surface of the snow.

The activity of this winter insect on the snow is limited by light intensity, temperature, and blowing snow. They are most

active during calm, sunny days when air temperatures reach 40°F (4.4°C) or more. *Chionea* avoid the lethal effects of freezing temperatures during cold weather by a process called *supercooling* or lowering the freezing point of their body fluids.

Unzicker and Brigham have studied these insects over three winters at two woodland sites in east-central Illinois to determine their distribution and population densities and to understand other aspects of their life cycle. Climatological data were recorded, including maximum-minimum air temperatures (above ground, at ground level above the litter layer, and at the soil surface under the litter layer), precipitation, and sky conditions. Additional studies planned for recent winters to characterize *Chionea* genetically have been hampered by unusually warm weather that restricts the activity of these winter-hardy insects!

The tulip tree pictured is a good tree for Arbor Day planting. It is decorative in early spring and gives good shade in the summer. Disease resistant, it is a sturdy, durable tree, and it grows quickly.

Arbor Day — A Holiday of the Future

In many countries, it has long been the tradition to hold a tree or forest festival annually. The origin of such celebrations must date back to antiquity, according to E. B. Himelick, plant pathologist at the Survey.

But the idea of calling a special day Arbor Day, as it is commonly known today throughout the world, evolved from the idea of one man living in the Great Plains of the United States. The idea spread widely to other countries where today it is variously celebrated as the "Festival of Trees," "Greening Week" in Japan, "The New Year's Day of the Trees" in Israel, the "Tree-Loving Week" in Korea, the "Afforestation Week" in Yugoslavia, the "Students Afforestation Day" in Iceland, and the "National Festival of Tree Planting" in India. Arbor Day, in its various forms, is now recognized in more than 50 countries.

The first Arbor Day was observed in the state of Nebraska on April 10, 1872. More than 1 million trees were planted in Nebraska on that day. During the 1870's, other states passed legislation to observe Arbor Day. Several United States presidents have proclaimed a national Arbor Day, but many states, because of different climatic zones, continue to celebrate the holiday at different times of the year. Most states observe the holiday on the last Friday of April, as we do in Illinois. Some do their actual tree planting on the state's own Arbor Day, which varies from January to February in the southern United States to May in the northernmost states.

The idea of Arbor Day was conceived by J. Sterling Morton, then a member of the Nebraska State Board of Agriculture. He was a journalist and became editor of Nebraska's first newspaper. Through his articles, he provided information on the use of trees and his suggested planting day, to be called Arbor Day.

J. Sterling Morton was tirelessly enthusiastic about planting trees. He realized that although the Great Plains were essentially treeless, they had the climate and the soils favorable for tree growth. His articles were about trees which were best suited to the area, and he encouraged the settlers to plant trees around their homesteads. Morton also advocated tree planting by schools, civic organizations, and groups of every kind.

The earliest recorded celebration of Arbor Day involving school children occurred on April 27, 1882. On that day, 21 trees were planted in Eden Park in Cincinnati, Ohio; one for each United States president up to that time. The first tree planted was a white oak, in memory of George Washington. Approximately 30,000 persons attended the tree planting. Schools let out, businesses closed, and many prominent persons attended. Eden Park now has an area called Presidents' Grove.

J. Sterling Morton, upon learning of the Arbor Day celebration in Cincinnati, was delighted to learn of the involvement of school children in planting trees on that day. Morton considered the adoption of Arbor Day by schools the most important aspect of the holiday's development. Mr. Morton died in 1902. One of his favorite sayings adorns a memorial marker to him in Nebraska City, Nebraska: "Other holidays repose upon the past; Arbor Day proposes for the future." Celebrated by children, Arbor Day is becoming a holiday of the future, for when a child plants a tree, not only is work done for which the community might benefit, but also for which he or she, in later years, might benefit.

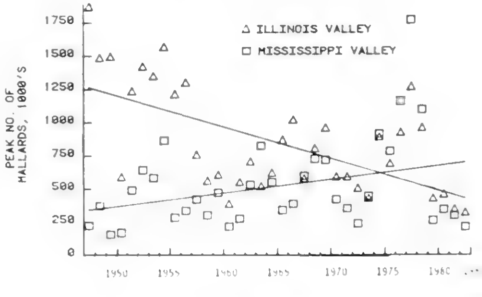
Probably one's first unconscious reaction to a community is caused by the absence or abundance of trees. It is frequently said that no single item distinguishes one city or town from another more than its green areas and streets lined with trees.

Trends in Mallard Numbers in Illinois

Each fall, thousands of waterfowl pass through Illinois enroute from their summer breeding grounds in Canada and the northern United States to their wintering grounds in Arkansas, Louisiana, Mississippi, and the Gulf Coast. Because Illinois lies between the breeding and wintering grounds for waterfowl in the Mississippi Flyway, it provides critical migration habitat for several species. Each day spent in Illinois during the fall migration provides waterfowl with an opportunity to rest and feed, and thereby to maintain their physiological condition at a level that will allow further migration. Days spent in Illinois also reduce the duration of stay on the wintering areas and, therefore, the amount of food that the wintering areas must provide.

Stephen P. Havera and Frank C. Bellrose, along with the staff of the Havana Field Station, are currently investigating the abundance and distribution of waterfowl throughout Illinois during the fall migration. Bellrose initiated the aerial inventories of the Illinois and Mississippi river valleys in 1948, thereby providing us with 36 years of continuous information on the waterfowl use of the rivers. Survey researchers believe that these inventories are the longest continuous series of waterfowl censuses in the United States. In 1971, Robert Crompton assumed the responsibilities of aerial censuses which have been expanded recently to include wetlands and rivers in northeastern, northwestern, central, and southern Illinois. Thus, although every duck that passes through Illinois each fall is not counted, there is a yearly index available of the numbers of approximately 20 species of waterfowl to use for comparison of trends in abundance, distribution, and chronology of migration.

The number of ducks that arrive at fall migration areas and the duration of their stay is determined by several factors. These factors include the size of the breeding population in the spring, the habitat and weather conditions on the breeding grounds, the conduciveness of weather conditions to migration along the flyway in the fall, and the amount of food and the presence of refuges on the migration areas. With this information, the long-term



Peak numbers of mallards censused each fall in Illinois and Mississippi River valleys, 1948-1983.

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trends of waterfowl use for these major migration sites can be examined.

In recent years, mallards have constituted approximately 50 percent of the nearly 400,000 ducks harvested annually in Illinois. In addition, mallards have represented about 86 percent and 47 percent of waterfowl use of the Illinois and Mississippi rivers, respectively, since 1960.

The highest number, or peak number, of mallards counted at any one time during the fall migration each year from 1948 to 1983 for the Illinois and Mississippi river valleys is shown in the accompanying figure. The Illinois River has always accommodated more mallards than the Mississippi River, but the difference in numbers is becoming smaller. The 10-year averages of the peak numbers of mallards counted for 1950-1959, 1960-1969, and 1970-1979 are 1,126,200; 652,800; and 767,400; respectively, for the Illinois River as compared to 440,300; 490,700; and 562,100 for the Mississippi River during the same periods. For the 1980-1983 period, however, the average of the peak number of mallards for both rivers has been substantially lower, averaging 374,500 for the Illinois and 277,800 for the Mississippi. The reduced numbers of mallards counted since 1980 are a reflection of the low level of the mallard breeding population and drought conditions on the breeding grounds. The peak number of 307,600 mallards in 1983 for the Illinois River was the lowest number ever counted since the inventories began in 1948. Similarly, the 1983 mallard peak of 212,200 for the Mississippi River was the lowest counted since 1950.

A comparison of the downward trend of mallard numbers using the Illinois River and the stable-to-slightly-upward trend of mallards inventoried on the Mississippi River can be explained by the waterfowl habitat associated with each river. In the Illinois River valley, wetlands have been degraded by sedimentation which has greatly reduced the variety and abundance of aquatic plants and other natural foods available to mallards.

In addition, the popularity of plowing harvested corn fields in central Illinois during the fall has sharply decreased the waste grain resource for mallards. By contrast, the aquatic plant life of the Mississippi River thus far has been less affected by sedimentation. Moreover, several public areas and refuges have been established during recent years in key locations along the Mississippi and these sites are being effectively managed for waterfowl.

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Society for the Illinois Scientific Surveys

The Natural History Survey, the Geological Survey, and the Water Survey have just initiated a not-for-profit corporation entitled the Society for the Illinois Scientific Surveys (SISS). Chief Paul Risser from the Natural History Survey is the first executive secretary, and a full board of directors is presently being appointed. As the society develops during the coming year, membership opportunities will become available, a publication will be produced, and several interesting field trips and educational activities will be presented.

The purpose of the society is to offer a means for more Illinois citizens to recognize, understand, and appreciate the state's natural resources by (a) providing information that is technically sound but comprehensible by the layperson, (b) organizing activities through which natural resources can be observed and discussed, (c) making programs of the three scientific Surveys widely known, and (d) nurturing various processes that permit the citizens of the state to supply data, information, and materials to the scientific Surveys. In a broad sense, the purpose of the society is to enhance the wise use and management of the natural resources of Illinois through support of the activities and programs of the three scientific Surveys.

Plans for the publication are not yet complete, but possible articles include the following:

(1) feature stories on topics of specific interest;
(2) feature series on topics of general interest, e.g., urban deer problems, contamination of aquifers, earth hazards (landslides, earthquakes, mine subsidence, etc.);
(3) monthly short information items such as pictures and descriptions of birds or spiders most likely to be seen, or the supply/demand outlook for Illinois' mineral resources;
(4) in-depth discussions, with data, about topics treated more superficially in the newspapers, e.g., erosion of Lake Michigan shores, better utilization of Illinois coal;
(5) commentaries about natural resources issues by well-known individuals in the state, e.g., governor, legislators, members of advisory boards;
(6) letters to the editor;
(7) a column where readers can ask questions to be answered by the Surveys' staffs; and
(8) a directory where specific services or information may be obtained.

Periodically, individuals and businesses wish to make contributions to the Surveys in the form of money, equipment, or property. Since the society will have a tax-exempt status, such gifts can now be received in a manner which benefits these donors.

The activities of the society will not replace the Surveys' responsibilities to the state. Rather, the society will assist the Surveys in dispersing information to the citizens of Illinois and elsewhere, and in providing a greater educational role for all three Surveys.

Winter Diving on the Mississippi River

What do river fish do in the winter time? How susceptible are these fish and

their habitats to disturbances from dredging activities or winter barge traffic? Until recently, river biologists have only speculated on the answers to these questions. In January, however, Survey biologists from the Grafton field station cooperated with other state and federal agencies and commercial divers to make first-hand observations under the ice cover of the Mississippi River, a first vital step to answering the above questions.

Visual observations of the bottom of the river are possible only during the winter, when water clarity extends beyond 2 or 3 feet. Ken Lubinski led the research team that compiled 20 hours of "down time" at five sites on Navigation Pool 13, Mississippi River, between Belleview, Iowa, and Savanna, Illinois. Most of the dives were made by Robert Anderson, Great Lakes Consultants, Inc., out of Traverse City, Michigan. Dives averaged about an hour in length.

The divers used specially designed drysuits for thermal protection. Air was supplied by large-volume tanks on the surface of the ice connected to the diver's helmet by an umbilical cord. At each site, groundlines were deployed to guide the diver and provide reference points for his observations, which were communicated by microphone wires to the surface where they were recorded in a dive log. Still photographs and video tapes were also made.

Of the five main channel sites explored, two had been used previously as experimental thalweg (the deepest part of the channel) disposal sites by the U.S. Corps of Engineers. At these sites, dredged material, mostly sand, was removed from areas where it might impede navigation and deposited in the thalweg.

Several unexpected observations were made by the dive team. Rather than being uniformly barren sand flats and dunes, as was previously thought, three of the five sites (including one disposal site) turned out to have mixed substrates of gravel and cobbles and supported large numbers of mussels. Large concentrations of dormant flathead catfish, ranging from 2 to 35 pounds, were observed seeking shelter in and around log piles at two sites. Other fish species included channel catfish, logperch, silver chub, gizzard shad, silver lamprey, and shovelnose sturgeon. At the edge of one disposal site, deposited sand graded immediately into large numbers of mussels on firm substrate, indicating that some mussels, as well as periphyton and aquatic insects, had probably been buried during disposal.

The observations suggested that catfish and shovelnose sturgeon, because of their dormant behavior, would be the most susceptible species to winter disturbances. The variety of habitats, substrates, and organisms observed resulted in a recommendation to survey or sample future sites before disposal to eliminate any chance of burying aquatic populations or valuable habitats under sand.

Robert Anderson, principal diver, prepares to descend to the bottom of the Mississippi River. Assisting him are Tim Adamsky and Greg Busch.

Birds and Woodlots

Reduction of total forest area and the fragmentation of native forest into isolated patches have affected populations of many bird species adversely, especially those songbirds that winter in the tropics. Because forest habitat is also disappearing at an alarming rate in Latin America where these birds winter, there is an urgent need to determine the area requirements of those species that depend on forest interior habitat.

In a study funded by the U.S. Fish and Wildlife Service, researchers at the University of Illinois, Department of Ecology, Ethology, and Evolution, studied birds in 15 woodlots in east-central Illinois. Their goals were to determine how many species disappear as the area of woodlots decreases and what species are least able to maintain populations in small woodlots.

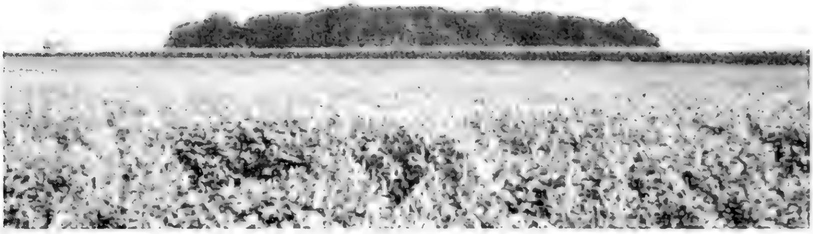
After censusing bird populations, John Blake and James Karr (who has an affiliate appointment at the Natural History Survey) showed a strong correlation between area of woodlot and number of breeding species. A 1,500-acre woodlot supports about 40 species of breeding birds. At 100 acres, only 30 species remain and 5-acre woodlots support only 10 to 15 species.

Species that winter in Central and South America seem especially susceptible to local extinction in the face of habitat fragmentation. In contrast, numbers of permanent residents and, especially short-distance migrants, were not strongly correlated with forest area. Short-distance migrants generally do not require forest interior habitat for breeding, and they are not as likely to suffer population reductions following forest fragmentation. These findings are similar to those reported from the Middle Atlantic states in 1979.

Many warblers, vireos, thrushes, gnatcatchers, tanagers, and flycatchers are among the neotropical migrants most dependent on large tracts of forest for nesting. Examples of the smallest tract on which birds were found during the breeding season in east-central Illinois are 1,500 acres for the hooded warbler; 290 acres for the American redstart; 160 acres for the Cerulean warbler; 70 acres for the Acadian flycatcher, the blue-gray gnatcatcher, the northern parula, and the ovenbird; and 40 acres for the scarlet tanager.

Although these species defend territories of only 2 to 5 acres during the breeding

Small woodlots such as this one in southern Piatt County, Illinois, are essential to the preservation of vanishing species of birds.



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season, a block of forest many times that large is needed to attract even small populations of these area-sensitive species. This concept must be taken into account in planning the acquisition and management of natural areas.

Much controversy over optimal size of natural areas has centered on the importance of small reserves and, in particular, whether two or more reserves equal in total area to a single large reserve will support more or fewer species. Despite inherent differences in species' biologies, few analyses of species occurrence in large or small forests have adequately addressed species composition (as opposed to species number) in relation to forest area. Consequently, many arguments over reserve size have not addressed a central purpose of many parks and reserves; that is, the preservation of species that are most at risk of extirpation or extinction. Blake and Karr used data from east-central Illinois to examine the relative benefit of multiple and small reserves versus single and large reserves. Although two small forests may, in some cases, hold more total species than a larger one, a single large reserve will preserve more of those species that are most dependent on forest interior habitat; that is, those species that are most at risk. Management strategies, to be most effective, must focus on species most in need of conservation efforts.

The conservation value of woodlots in highly disturbed landscapes such as east-central Illinois extends beyond the breeding season. During migration, many species pass through Illinois on their way to northern breeding grounds or southern winter grounds. Because migration is an energetically expensive activity, birds must be able to periodically replenish energy supplies. Because agricultural land provides little adequate habitat for most migrants, the presence of natural patches of habitat, such as woodlots, can be of great benefit. In many cases, species that breed only in very large woodlots use even small patches of forest during migration for foraging and resting. Large woodlots support greater numbers of species and individuals, but during spring and fall migratory periods, woodlots of almost any size provide valuable habitat for many species.

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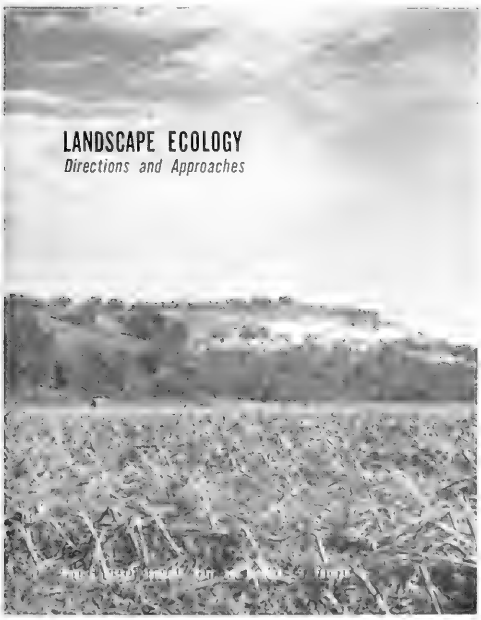
Special Publication On Landscape Ecology

In recent years a new field of science, called regional ecology or landscape ecology, has been emerging. Current ideas about landscape ecology are influenced by the theories, methods, and points of view of a number of scientific disciplines, and "these influences appear to have stalled the crystallization and communication of the current understanding of landscape ecology, especially as the concept might facilitate basic and applied research on natural resources." So wrote the authors of a recently published report titled, *Landscape Ecology: Directions and Approaches,* Illinois Natural History Survey Special Publication Number 2.



Cover of new special publication on landscape ecoolgy (Photo by R. A. Evers).

One method of speeding the integration of a landscape ecology approach was to gather together experienced individuals with different viewpoints but with a strong desire to examine landscapes through the ideas of ecology and related disciplines. With funding from the National Science Foundation, Dr. Paul G. Risser, Chief of the Illinois Natural History Survey, called together 24 other scientists for a workshop meeting on landscape ecology, to evaluate the potential of such a discipline, and to describe its application to basic and applied natural-resource issues.

Dr. Risser and two of the other project directors, Dr. James R. Karr of the Department of Ecology, Ethology, and Evolution, University of Illinois, and Dr. Richard T. T. Forman, Department of Biological Sciences (Botany), Rutgers University, took the materials of these meetings and fashioned them into a coherent series of statements about the scientific research approaches being used and the directions which research might take in the new field of landscape ecology.

Early in the report the authors point out that "Landscape ecology differs from subdisciplines of ecology, such as population, community, and ecosystem ecology, in matters of primary emphasis. Landscape ecology focuses explicitly upon spatial pattern. Specifically, landscape ecology considers the development and dynamics of spatial heterogeneity, spatial and temporal interactions and exchanges across heterogeneous landscapes, influences of spatial heterogeneity on biotic and abiotic processes, and management of spatial hetero-

geneity." They go on to say, "Principles of landscape ecology help to provide theoretical and empirical underpinnings for a variety of applied sciences, e.g., regional planning, landscape architecture, and natural-resource management."

Copies of this report may be obtained from the Illinois Natural History Survey, Natural Resources Building, 607 East Peabody Drive, Champaign, Illinois 61820.

Information System Being Developed

A computer-based natural resource information system is being developed at the Natural History Survey. The system contains data on the biological, geological, and hydrological resources of Illinois as well as cultural resources (anthropology and historical sites) and social and economic data. The system is a cooperative effort between five divisions of the Department of Energy and Natural Resources: Energy and Environmental Affairs, the Natural History Survey, the Geological Survey, the Water Survey, and the State Museum. A large amount of funding for the system has come through the Lands Unsuitable for Mining Program sponsored by the federal office of surface mining.

The natural resource information system is an important new research tool and a significant advancement in the management of natural resource data. It will stimulate new directions in research by allowing scientists to synthesize, analyze, and display large amounts of data within a geographic context. For example, researchers will be able to model the potential for insect infestations, habitat loss, mine land reclamation and other threats to natural resources. The relationships between factors such as vegetation and soil may be studied on a regional as well as a local scale. The system will also be used to maintain detailed inventories of the state's natural areas, streams, wetlands, and forests. Comprehensive data files are being compiled on the distribution and chacteristics of Illinois' fish, wildlife, and plants. Computer access to the data will allow responses to the public's need for natural resource data to be more timely and complete than what is now possible using manual methods. As a central repository, the system will improve archival storage and sharing of natural resource data.

The system is being developed on a Prime 750 minicomputer located in the Natural Resources Building in Champaign. Communication lines give all five Energy and Natural Resources divisions direct access to the system. Each division is equipped also with a graphics work station to be used for data entry and analysis. A graphics work station consists of a digitizer and a graphics terminal. A digitizer is a special device resembling a light table and is used for encoding map information. The graphics terminal is a TV-like device used to display the data once it has been entered into the computer. The system has three pen blotters which can produce maps and other graphics in four colors at speeds up to 18 inches per second. A colorgraphic recorder is available to produce color slides or 8 x 10 prints. The system has been under development for almost 2 years. Computer operations began in September 1983. Recent efforts have been concentrated on training staff and installing data on the system.

It's Boring

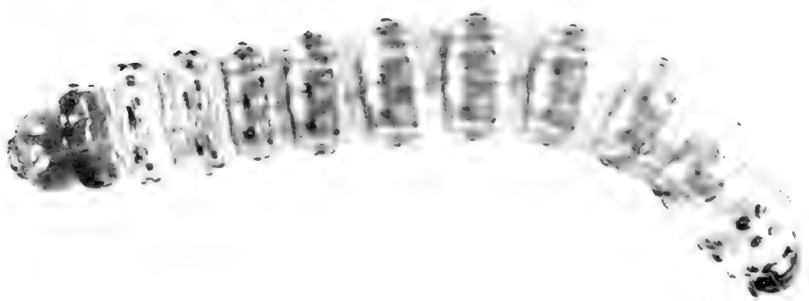
Survey entomologists studying corn insects were baffled for several years by a "mystery" borer that sporadically was detected in the stems of young field corn in the northern one-third of Illinois. The caterpillar was first noticed in Kane County during July 1978 and as far west as Carroll County in subsequent years; and Wisconsin researchers recently have seen it in Manitowoc County of that state. Efforts to identify the caterpillars were unsuccessful until a single specimen was reared to the moth stage in 1983 by entomologists George L. Godfrey and Eli Levine. The moth proved to be *Amphipoea americana* Speyer, a moderately common species but whose caterpillar has not been described.

The caterpillar of *A. americana* is very similar to the hop vine borer, *Hydraecia immanis* Guenée, which was discussed in *Survey Reports* No. 196 (April 1980) and described along with the potato stem borer, *H. micacea* (Speyer), in Illinois Natural

History Survey Biological Notes No. 114 (February 1981). Similarities include physical appearance and the same geographical distribution (in Illinois). Another species with which it may be confused, at least in the earlier larval stages, is the stalk borer, *Papaipema nebris* Guenée (see *Survey Report* No. 228 (June 1983).

Levine hypothesizes that acreages of corn planted using reduced tillage practices may result in increased populations of *A. americana*. Published information on this species is very meager, and it is impossible to ascertain the species's potential economic significance until the basics of its life history and host plant preferences are understood. Therefore, Levine is planning to study its ecology feeding damage on corn in 1984 to clarify the situation. Godfrey will be supporting the work by assessing morphological characters that may be used by other researchers to help distinguish *A. americana* caterpillars from other corn boring caterpillars. Persons suspecting that they may have this species are encouraged to contact either Godfrey or Levine at the Survey (see the address on page 4 of this issue).

Mature caterpillar of *Amphipoea americana* 25 mm in length (Photo by G. L. Godfrey).



Mature caterpillar of the hop vine borer, *Hydraecia immanis*, 30-35 mm in length (Photo by G. L. Godfrey).

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WILLIAM LUCKMANN COMPLETES 35 YEARS OF PUBLIC SERVICE

Dr. William H. Luckmann retired from the Illinois Natural History Survey on August 31 after serving as Entomologist and Head of the Section of Economic Entomology since 1965. Dr. Luckmann began his long career at INHS as a research assistant in the Section of Economic Entomology in 1949.

Dr. Luckmann's chief research interests have been in corn entomology and the environmental impact of pesticides. In the field of corn entomology, he has been particularly concerned with the European corn borer, the corn rootworms, and the black cutworm, insects of overwhelming consequence to producers of corn in Illinois. His work on the environmental impact of insecticides has manifested itself in the monitoring of pesticide residues in crops, soil, and wildlife. He has been particularly concerned that Illinois agricultural producers not find their products unmarketable because of residues.

Dr. William H. Luckmann
(Photo by Les Woodrum)

Dr. Luckmann's research endeavors have led to the formation of effective pest-management programs that serve to maximize crop protection with minimal environmental disruption.

Through the medium of the widely accepted book *Introduction to Insect Pest Management* that he co-edited with Dr. Robert L. Metcalf, he reached large numbers of students and crop protection specialists here and abroad with his philosophy of modern pest management.

In his administrative role, Dr. Luckmann structured his staff into effective teams of researchers that have enjoyed considerable success in combating the pests of corn, soybeans, alfalfa, fruit crops, ornamental plants, and vegetable crops. He has also encouraged his staff to become involved in international programs in agriculture in the certain knowledge that a broader base of experience would help in solving the problems confronted by Illinois agriculture, and he himself studied and consulted in India, Iran, and Puerto Rico.

Dr. Luckmann's leadership in research, administration, and education has gained him national and international recognition. He served as President of the North Central Branch of the Entomological Society of America in 1978 and 1979. From

A young Bill Luckmann working on corn borer research with Dr. George Decker. It was part of Luckmann's thesis in March 1950 (photo by C. L. Scott).

Dr. Luckmann using hand sprayer on corn earworm in 1952 (photo by W. E. Clark).

Sitting on commercial sprayer, he is again spraying for corn earworm near Rochelle, Illinois in 1952 (photo by W. E. Clark).

Sorghum plant heads are examined for insects. Picture was taken in 1957 (photo by W. E. Clark).

In 1964 he was releasing Tiphia wasps, parasites of the Japanese beetle.

Section Heads meet with Dr. George Sprugel in 1967. Dr. Luckmann is on the far left. Left to right are Dr. Herbert Ross, Faunistic Surveys and Insect Identification; Dr. George Bennett, Aquatic Biology; Dr. Cedric Carter, Botany and Plant Pathology; and Dr. Glen Sanderson, Wildlife Research (photo by W. D. Zehr).

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Clarence White and Luckmann release ladybugs in corn and alfalfa fields in 1975 (photo by Larry Farlow).

1977 to 1979, he was Chairman of the Pesticides Subcommittee of the Task Force on Agricultural Nonpoint Sources of Pollution. He is listed in *American Men and Women of Science* and *Who's Who in America*.

A native of Cape Girardeau, Missouri, he began his long career at INHS as a research assistant in the Section of Economic Entomology in 1949. He received an appointment as Assistant Entomologist at INHS in 1951, the year that he received his M.S. degree in entomology from the University of Illinois. In 1954 he was promoted to Associate Entomologist, and 2 years later he received his Ph.D. degree in entomology from the University of Illinois. He was promoted to Entomologist at INHS in 1959.

In addition to his appointments at INHS, from 1965 until his retirement he served as Head of the Office of Agricultural Entomology in the College of Agriculture at the University of Illinois and as Professor of Entomology in the Department of Entomology of the School of Life Sciences at the University of Illinois.

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NATURAL HISTORY SURVEY REPORTS

Pruning Shade Trees

Trees must receive regular maintenance for rapid growth and good health, according to E. B. Himelick, Survey plant pathologist. Such maintenance includes watering, fertilizing, pruning, spraying with pesticides, surgery, bracing and cabling, preventing grade changes, and protecting against chemical and lightning injury. Proper pruning is often neglected for too long and trees become hazardous and require extensive corrective measures.

Magnificent trees of almost every species grown on the home grounds are deformed by "local talent" tree trimmers. Himelick says these trimmers, through ignorance or the need for an extra dollar, tend to cut entire tree tops or sides of the crown, leaving only the trunk and large stubs. Such trees are either killed outright or, if they survive, produce vigorous sucker growth with short-lived crowns and ugly form. The stubs left by this practice will eventually decay and produce only a shell to support future growth of large branches.

Pruning should be done by an experienced arborist with on-the-job training, proper equipment, and one who is familiar with the techniques and hazards of working on large trees. The use of climbing spurs or irons is not recommended and should not be used on living trees.

Crown reduction should be done on a continual basis to avoid extensive pruning any one year. The growth habit of a particular species dictates how the tree should be pruned.

Excessive pruning by severely cutting back all major branches frequently results in dying back of the injured branches (photo by Ray Hamm).

Extensive pruning of large branches or leaders usually results in the production of thick masses or clumps of slender, weak branches (photo by Ray Hamm).

There are four types of pruning: fine, medium, coarse, and drop-crotch. Fine pruning is the most extensive and includes the removal of dead, dying, diseased, and interfering branches and selective thinning to decrease wind resistance. Medium pruning is similar but generally is a less severe type of pruning. Coarse pruning consists only of removing dead and weakened branches 2 inches in diameter and larger. Drop-crotch pruning consists of top and side reduction through the selective removal of vertical and lateral branches. All pruning cuts should be made close to the trunk or parent limb, without cutting into the branch collar or leaving a protruding stub, so that bark-callus closure can develop. When done properly, this type of pruning involves cutting branches back to lower lateral branches having at least one-third the diameter of the branches removed.

Drop-crotch pruning is used when branches interfere with utility lines, when major branches or root systems are severely damaged, or when unusual and rapid branch growth in the tops or sides of tree crowns occurs. This type of pruning may be required periodically on fast-growing trees such as silver maple, Siberian elm, and willow. Drop-crotch pruning is basic to any pruning operation and is used to reduce the height and spread of the crown while retaining its natural shape.

Tree crowns are sometimes pruned or thinned to increase the vigor of remaining branches. Opening the crown permits more light penetration and stimulates lateral bud growth. Selected removal of excessive succulent growth will encourage the development of strong branching laterals and increase the general vigor of crown development.

Judicious pruning of trees with weakened branches or damaged root systems will lessen wind resistance and weight of the crown. Thinning and drop-crotch pruning requires both skill and time and if done correctly, it will benefit both the tree and its aesthetic appearance. The best compliment an arborist can receive after major pruning is having the average person fail to notice a tree has been pruned. Pruning standards published by the National Arborist Association offers general guidelines followed by most arborists.

Homeowners should be aware of the responsibilities they have in the preservation of their trees. Old trees that decline and have weak and dead branches can often be kept healthy for many years through proper pruning. Wood-chip mulch, fertilization, proper watering, and disease and pest control practices will also be beneficial in prolonging the life of a valuable tree. Much thought should be given to proper tree selection and planting location to avoid the expense of extensive corrective pruning years later.

Food, Fiber, and Fugitive Insects

Among the many specimens submitted to systematists of the Illinois Natural History Survey for identification during 1983 were two species of insects and one of an insect-ally, a tick, which represents first detections for the state.

The newcomers included two species of long-horned beetles which breed in dead and dying pine trees. These beetles are potential carriers of the pinewood nematode, a causative agent of pine wilt which has been very destructive to pines in Illinois in recent years. The newly detected tick is of veterinary importance and, in addition, is believed to be a cause of tick paralysis in man. Two of the migrants undoubtedly moved into Illinois from adjacent states, and one was seemingly introduced from overseas.

The phenomenon of the active dispersal and passive transportation of pest species of insects into Illinois from neighboring continental areas and from elsewhere is well-known and obviously continuing. Readers of *Illinois Natural History Survey Reports* will be aware of such examples as the alfalfa weevil, the imported crucifer weevil, the western corn rootworm, and the gypsy moth. A recent estimate of the Entomological Society of America numbers the major and minor pest species that have been introduced into the borders of the United States to be more than 800. According to that study, among the imported species are a number of serious pests which

collectively are responsible for over 50 percent of all insect losses in the United States.

The migration of pest species from outside the state is not a recent development in Illinois. Benjamin Walsh, a pioneering entomologist who became the first State Entomologist of Illinois in 1867, wrote an article on the subject of imported and migrating insects as early as 1866. Writing from Rock Island, he stated that fully one-half of the worst pest species known in America at that time were known to have been imported from Europe. Walsh was also familiar with range adjustments in native insects. In documenting the arrival of the Colorado potato beetle in Illinois in 1864, he noted that it was the first record of a pest species spreading from the western United States to the east. All previous importations and migrations had been from the east. An interesting example of an insect that arrived in Illinois from the south is provided by the boll weevil. Although the boll weevil was detected in Illinois several decades ago, the fact is little known even among entomologists because of the minor extent of cotton production in Illinois.

Because of the continuing arrivals of new pest species in the state, crop protection specialists in Illinois face a difficult task. As resident pests are studied and brought under scientific management, new pests arrive on an almost yearly basis. The systematists of the Illinois Natural History Survey work to insure that these invaders will be promptly and correctly identified upon their first detection in the state.

Years of first detection in Illinois of some insects and insect allies of economic importance.

1938 JAPANESE BEETLE, *Popillia japonica* Newman (on ornamentals)
1939 EUROPEAN CORN BORER, *Ostrinia nubilalis* (Hubner)
1940 IMPORTED LONGHORNED WEEVIL, *Calomycterus setarius* Roelofs
1953 JAPANESE BEETLE (on field crops)
1957 MIMOSA WEBWORM, *Homadaula anisocentra* Meyrick
1959 FACE FLY, *Musca autumnalis* De Geer
1959 BROWN RECLUSE SPIDER, *Loxosceles reclusa* Gertsch & Mulaik
1963 SOUTHWESTERN CORN BORER, *Diatraea grandiosella* (Dyar)
1964 ALFALFA WEEVIL, *Hypera postica* (Gyllenhall)
1964 WESTERN CORN ROOTWORM, *Diabrotica vergifera vergifera* LeConte
1965 AZALEA LEAF MINER, *Caloptilia azaleella* (Brants)
1965 CEREAL LEAF BEETLE, *Oulema melanopus* (Linnaeus)
1966 LONE STAR TICK, *Amblyomma americanum* (Linnaeus)
1967 ASIATIC OAK WEEVIL, *Cyrtepistomus castaneus* (Roelofs)
1973 GYPSY MOTH, *Lymantria dispar* (Linnaeus)
1974 SOUTHERN GREEN STINKBUG, *Nezara viridula* (Linnaeus)
1976 TWOBANDED JAPANESE WEEVIL, *Callirhopalus bifasciatus* (Roelofs)
1977 IMPORTED CRUCIFER WEEVIL, *Baris lepidii* Germar
1979 HONEYSUCKLE APHID, *Hyadaphis tartaricae* (Aizenberg)
1983 GULF COAST TICK, *Amblyomma maculatum* Koch
1983 A Longhorned beetle, *Neoclytus muricatulus* (Kirby)
1983 A longhorned beetle, *Xylotrechus sagitattus* (Germar)
1984 WHITESPOTTED SAWYER, *Monochamus scutellatus* (Say)

Two Recent Survey Publications

Recreational Fishing in the Kankakee River, Illinois by Robert J. Graham, R. Weldon Larimore, and William F. Dimond is a recent publication in the Illinois Natural History Survey Biological Notes series. This 13-page booklet reports the findings of a 2-year study of the fishermen, fishing effort expended, and fish harvest in the lower Kankakee River and related information.

The researchers found that fishing effort averaged 3,823 man-hours per kilometer per year. Although most of this effort was not expended in pursuit of any particular fish species, the three species caught in greatest numbers were the carp, channel catfish, and shorthead redhorse. The mean annual catch rate for all fish species was 0.13 fish and 56.7 grams of fish per man-hour of fishing effort. The estimated total harvest was 469 fish weighing 217 kilograms per kilometer per year.

A profile of the people fishing the river,

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the methods they used, their reasons for fishing in the Kankakee, and similar information of interest to fishermen, fisheries managers, conservationists, and others is presented in this booklet.

Another recent publication in the Biological Notes series is *Bibliography of Illinois Vegetation* by Paul G. Risser, Chief of the Illinois Natural History Survey. Dr. Risser has gathered together a list of 1,277 publications about the plant life of Illinois and has presented them in bibliographic style to assist researchers, naturalists, and others interested in the vegetation of our state. He has classified also the literature in five indexes.

As Dr. Risser points out in his introduction, "The vegetation of Illinois has been studied for more than 100 years. These studies have produced a rich literature describing the plant communities. . . .

"Collectively, this literature constitutes the basis for a number of thoughts and themes about plant ecology — ideas that originated from the work of ecologists who worked in plant communities in Illinois. . . . The literature on the vegetation of Illinois is impressive in its volume and quality and, as such, represents a sound base upon which to build further studies on the plant communities of the state. At the same time, this bibliography, and the individual indices, indicate that biologists still have enormous opportunities for rewarding investigations on the vegetation of Illinois."

To obtain these or other Survey publications, write to the Illinois Natural History Survey, 172 Natural Resources Building, 607 East Peabody Drive, Champaign, Illinois 61820.

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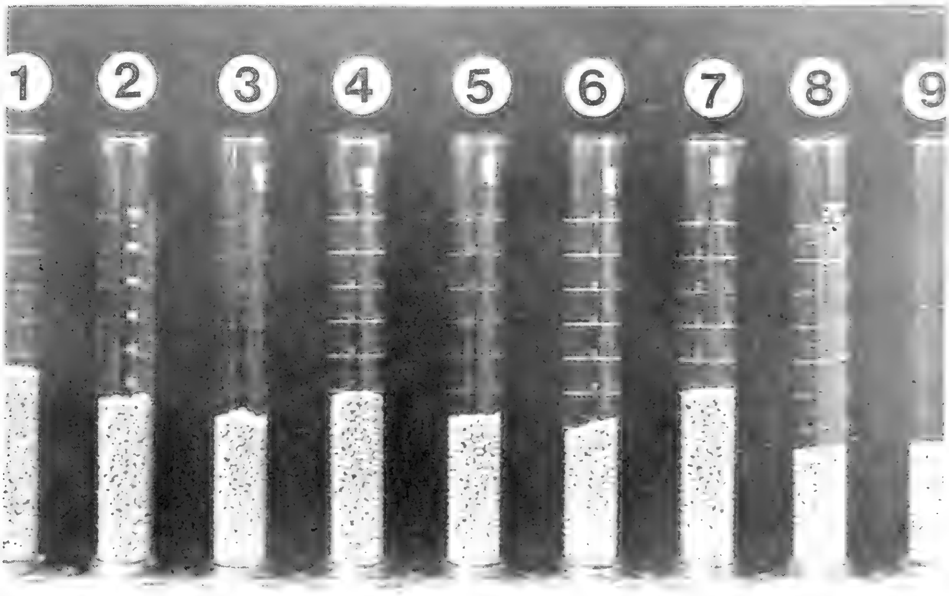
Air Pollution and Illinois Soybean Production

The variety, quantity, and pervasiveness of materials added to the environment concern many persons. These materials include gases, agricultural chemicals, and particulates to the atmosphere, sewage and chemicals to water systems, and solid wastes to the land. Whether they act alone or together, environmental pollutants affect man's food supply, health, and well-being, sometimes adversely. "Smog," or air pollution, is usually identified with large cities, such as Chicago, St. Louis, Los Angeles, or New York. However, scientists are aware of and often disturbed by the apparent increase of air pollutants in non-metropolitan and rural areas whose economic base is frequently agricultural. Indeed, clean air is not the normal environment for plant and animal growth in many locations.

Environmental quality has been a major interest of Illinois Natural History Survey scientists for a long time. The Survey's participation in environmental studies includes investigations of plant-air pollution interactions. Anton G. Endress of the Botany and Plant Pathology Section has con-



Comparisons of soybean yield of plants exposed to ozone alone, sulfur dioxide alone, or mixtures of ozone and sulfur dioxide in greenhouse studies. Cylinder 1 (extreme left) shows the yield from the control plants that received greenhouse air during their development. The addition of ozone alone to greenhouse air reduced soybean yield (compare cylinders 2 and 3 to control), but the addition of sulfur dioxide alone to greenhouse air had no effect on yield (compare cylinders 4 and 7 to control). Mixtures of ozone and sulfur dioxide also reduced soybean yield (compare cylinders 5, 6, 8, and 9 to the control) as much as or more than when ozone only was supplied (Photo by Anton Endress).

structed a chamber system to examine the effects of exposure to air pollutants on the development, growth, yield, and quality of plants.

Endress and a colleague, Claus Grunwald, have recently completed a study of soybean growth and development as it is affected by mixtures of ozone and sulfur dioxide, the two most common gaseous air pollutants in Illinois. Soybeans were examined because Illinois is a leader in soybean production in the United States and several studies have shown that soybeans are sensitive to air quality.

Soybeans (cultivar "Corsoy") were raised in the greenhouse for an entire season. During their growth, the soybeans were exposed to ozone alone at three concentrations for a total of 260 hours, to sulfur dioxide alone at three concentrations for a total of 42 hours, or to mixtures of both ozone and sulfur dioxide. Throughout the study, plants were periodically removed, cut apart, and weights of the various organs determined. At the end of the experiment, the remaining plants were harvested for seed yield.

The periodic plant harvests allowed Endress and Grunwald to evaluate the dynamic response of the soybeans to air pollutant stress. They determined that the air pollution treatments reduced total plant biomass and leaf area. The harvested seeds also showed a response to the presence of air pollutants. Ozone by itself caused reductions of seed weight per plant and weight per seed, while sulfur dioxide alone had no demonstrable effect. However, the mixtures of ozone and sulfur dioxide produced the greatest yield reductions (as much as 38 percent) with fewer pods and seeds per plant and smaller seeds.

Although the results are incomplete, there is apparently no effect of either ozone or sulfur dioxide on the protein content of the seeds.

Growth and yield reductions in soybeans caused by air pollutants have been known for some time and have occurred when leaves showed visible markings. The unique findings of these Survey studies are that growth and yield were reduced even though the plants demonstrated no observable symptoms. Furthermore, the scientists were able to isolate the effects of sulfur dioxide and ozone when the plants were exposed to a mixture of these two pollutants.

Stalk Borer Oviposition

The stalk borer, *Papaipema nebris,* can be a serious pest of seedling corn, particularly of corn planted using conservation or reduced tillage practices. Female moths are thought to deposit their eggs on vegetation or plant debris in fence rows, contour strips, grass waterways, or in weedy fields during late summer and early fall. After the eggs hatch the following spring, the larvae begin feeding on grasses but move to larger plants as they outgrow their original hosts. Corn may serve as this larger plant if planted in or near infested fields.

To learn which fields might serve as preferred egg-laying sites for the stalk borer, Survey entomologist Eli Levine recently determined the ovipositional preference of female moths in cage tests among a variety of weeds and plant debris representative of that found in or immediately adjacent to corn fields damaged by this pest. In additional cage tests, the ovipositional preference of female moths among various cover crops typical of those planted under the United States Department of Agriculture's payment-in-kind (PIK) crop diversion program was examined.

In the first cage experiment, Levine found that quackgrass and giant foxtail were highly preferred by ovipositing moths,

Stalk borer eggs deposited on quackgrass. Notice how most of the eggs are laid between curled sections of leaf (Photo by Eli Levine).

while dead foxtail stems, corn stalk debris, and giant ragweed were less preferred. In the second cage experiment using PIK cover crops, orchardgrass and dead winter wheat were among the most highly preferred cover crops tested, while red clover and alfalfa were among the least attractive. The results of Levine's study suggest that female moths prefer to lay their eggs on plants in the grass family, particularly species with numerous leaf sheaths and/or folded or rolled leaves.

Wild females probably behave in a similar manner and oviposit on grasses in fence rows, grass waterways, or contour strips. Oviposition may occur in crop fields if grasses are present during the period moths are laying their eggs (late summer and early fall).

Fields containing these preferred plant species should be closely monitored the following spring for stalk borer infestations if these fields are planted to corn using reduced tillage methods. Good grass control within a field is essential in preventing recurring outbreaks of this pest. Corn producers wishing to participate in a study to evaluate the effectiveness of this technique should contact Levine at the Survey.

WILLIAM F. CHILDERS 1922-1984

DR. WILLIAM F. CHILDERS

In January 1953, while still an undergraduate student, William F. Childers was employed by the Illinois Natural History Survey to help in the trapping and tagging of ducks at the Havana Laboratory. Although it was so cold those first few months that Bill frequently had to chop duck traps out of the ice, he slept in the unheated *Anax,* the Survey's river research boat that had been pulled up in dry dock. From the very beginning of his professional career, Bill Childers had a tough intimacy with natural systems.

In June of that year, Bill began working with Weldon Larimore on warmwater streams, beginning a close professional and personal association that lasted throughout Bill's career. During the following 3 years while working with stream fishes, Bill also studied the behavior of black and white crappies with Professor Hurst Shoemaker, which led to the master's degree in 1956. His first professional honor came when a paper that he and Larimore published on intermittent streams was recognized as the best technical paper published in Volume 88 of the *Transactions of the American Fisheries Society.*

In June 1956, Bill left the stream investigations to work with George Bennett on fish populations of ponds and lakes. With Bennett's consistent encouragement, Bill began his study of hybrid sunfishes that led to his Ph.D. degree in 1965 and to a paper that was judged by the Wildlife Society to be the best fisheries paper published in North America in 1967. Studies of fish genetics occupied his interest for the rest of his career.

With his protege, David Philipp, and with Professor Greg Whitt of the University of Illinois, Bill developed a strong progressive program in fish genetics, which earned both national and international recognition. Bill was twice invited to the USSR to lecture and to attend symposia, and just weeks before his death a paper which he published with Philipp and Whitt received recognition as the best paper of

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Volume 112 of the *Transactions of the American Fisheries Society.* Probably no other American fishery biologist has received such honors for three separate scientific investigations

Bill was a craftsman with great skill and imagination. As his work demanded, he designed and constructed various traps and weirs and showed exceptional creativity in solving technical problems in both the field and laboratory. He was always generous in sharing these abilities with his colleagues.

His deep interest in fish and game behavior and habitat, supported by many special skills with rod, gun, and dog, made Bill an enthusiastic and successful sportsman. He made each cast with the concentrated intention of catching a fish, and with each shot he intended to bring down game. His enthusiasm for fishing and hunting and his high standards for courtesy among sportsmen made Bill a pleasant companion in the field.

Bill was a superb storyteller, with fantastic recall of incidents and details of special episodes. He used storytelling not only in communication but also as an art form — an art form in which he excelled.

Bill died September 20, 1984. To that day, he retained his keen scientific interest in finding the right answers and in drawing the proper conclusion; but his sometimes severe scientific discipline was always tempered by a kind and generous nature, a delightful sense of humor, a great love of people, and a joyful enthusiasm for whatever he was doing.

Recent Publications

Duffield, R. M., W. E. LaBerge, and J. W. Wheeler. 1984. Exocrine secretions of bees — VI. Aliphatic esters in Dufour's gland secretion of *Svastra obliqua obliqua* (Hymenoptera: Anthophoridae). Comparative Biochemistry and Physiology 78B(1): 47-50.

Graham, R. J., R. Weldon Larimore, and William F. Dimond. 1984. Recreational fishing in the Kankakee River, Illinois. Illinois Natural History Survey Biological Notes No. 120. 14 p.

Page, L. M., and D. L. Swofford. 1984. Morphological correlates of ecological specialization in darters. Environmental Biology of Fishes 11:139-159.

Page, L. M., and K. S. Cummings. 1984. A portable camera box for photographing small fishes. Environmental Biology of Fishes 11:160.

Perry, L. G., and John A. Tranquilli. 1984. Age and growth of largemouth bass in a thermally altered reservior, as determined from otoliths. Journal of Fisheries Management 4:321-330.

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Bird Communities of Amazonian Forests

Western Amazonia contains the richest, but least understood, bird communities in the world, according to Scott Robinson, Survey ornithologist. Several lowland sites have nearly 550 species in areas of less than 19.5 square miles. These small areas contain far more species than have been recorded in the entire state of Illinois. One of these sites, the Cocha Cashu Biological Station in southeastern Peru, has been the site of a long-term study of bird community dynamics since 1973. This site is located in the huge (3.7-million acre) Manu National Park, an area that still contains uncontacted tribes of natives. It takes 5 or 6 days to get to the biological station from Cuzco, the nearest city, 2 days by truck and 3 or 4 days by dugout canoe from the end of the road. The sheer inaccessibility of the site has protected it from logging and systematic hunting. For this reason, the Manu Park has a full complement of species, including many large predators at natural population levels. Large cats, including jaguar, puma, and ocelot, walk the forest

The tree pictured is a *Sloanea*, one of a large genus of tropical timber trees (family Elaeaocarpaceae) having alternate leaves, small petal-less flowers with numerous stamens, and usually very hard wood (Photo by William O. Robinson).

at night. Many large birds that have been hunted to extinction elsewhere are still common and easily found inside the park boundaries. Thirteen species of monkeys, nearly all of which are remarkably tame, abound in the area around the station. In short, the Manu Park provides an excellent opportunity to study pristine communities of birds and mammals. Results of these studies can be used to gain perspectives on the far more disturbed forests of North America, including those in Illinois.

In September and October, Robinson took a leave of absence from the Survey to continue an intensive study of the Manu bird community in collaboration with John Terborgh of Princeton University. This project, funded by the National Science Foundation, involves a large-scale census of the birds found in each of the major habitats of the Manu Park and an investigation of the factors that determine which species occur in each habitat.

Mature forest, which is exceedingly complex in structure, contains the greatest number of species (240 species per 250 acres), whereas the structurally simple successional vegetation along river edges contains the fewest species (85 species per 250 acres). However, both habitats contain 5 to 10 times more species than do habitats of comparable vegetation structure in Illinois. Tropical birds, however, are rarer on the average than birds of temperate forests. Roughly 190 of the 240 species found in mature forest have population densities of fewer than 5 pairs per 250 acres. Many small insectivorous birds have territories of 12-49 acres, which is 5 to 10 times larger than those of comparably sized birds in temperate forests. Apparently, the tremendous increase in species richness of tropical forests comes at the expense of decreased population densities of each species.

Neotropical migrants, many of which breed in or pass through Illinois, are largely restricted to river edge and successional habitats on their winter grounds in southeastern Peru. Shorebirds, including 13 species that migrate through the Midwest, occur on the beaches that are exposed when the river level drops during the dry season (June to November). Such familiar Illinois species as Eastern Pewee, Eastern Kingbird, and Swainson's Thrush are most abundant in floodplain forests dominated by mahogany, figs, and trees of the laurel family. Unfortunately, these river-edge forests are the first to be logged and converted to agriculture following human settlement. Very few North American species winter in mature upland forest, which covers most of the Amazon basin.

Robinson and Terborgh have found evidence that interspecific aggression also may play a key role in determining which species occur in each habitat. A common pattern is for closely related species to occupy different habitats. In the Manu area, often one species occupies early successional vegetation and another from the same genus occupies mature forest. In these pairs of species, one is usually dominant over the other. The dominant species attacks when it hears the song of the subordinate. The subordinate species, in turn, usually retreats when it hears the song of the dominant. Apparently the dominant species, generally the larger of the two, occupies the preferred habitat and forces the smaller one into marginal habitat. To date, this relationship has been found in 12 of 14 genera tested. These results suggest that interspecific competition may be widespread and important in determining habitat selection in Amazonian birds.

Nest predation also plays a key role in determining habitat selection in many Amazonian birds. Many arboreal mammals (including most monkeys), snakes, hawks, and even toucans are inveterate predators of the eggs and young of birds. Though few species have been studied in detail, predation rates for some species probably approach 90 percent of all nests. To escape predation, birds must either hide their nests in tree holes or dense vine tangles or nest in areas where monkeys cannot reach them. Isolated trees, such as those on islands, are often covered with nests of many species, some of which are colonial. The availability of such safe nest sites may play an important role in limiting the populations of many tropical species.

Such studies of tropical bird communities can provide valuable insights into

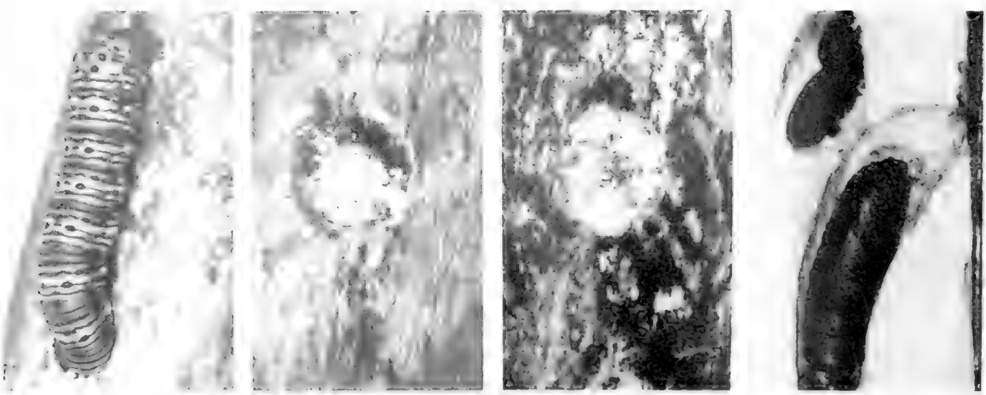
what factors might also be structuring temperate communities. Competitive interactions, which appear to be important in a great many tropical genera may also be important in the temperate zone, where many closely related species occupy different habitats. Similarly, nest predation may be far more important in temperate bird communities than is generally recognized. Perhaps the major advantage of working in the temperate zone is that many species are common and therefore relatively easy to study. Therefore, tropical forests provide the opportunity to study ecological interactions between many species, while temperate habitats provide an opportunity to study fewer species in much greater detail.

Snug As a Bug in a. . . . .

Pearly wood nymph caterpillars (*Eudryas unio*) begin abandoning the leaves of their host plants, evening primrose (*Oenothera*), willow herb (*Epilobium*), and grape (*Vitis*), in late September and early October in search of suitable pupating and overwintering sites. Many of *Eudryas unio*'s 3,000 moth relatives in North America unobtrusively construct pupation chambers in the duff, or below the soil surface. In contrast, *E. unio* prefer to pupate in soft wood or the stems of large, erect herbs and excavate their chambers with remarkable persistence. One Madison County resident near Edwardsville observed this activity in September 1983, reporting to the Survey that "thousands" of caterpillars (identified as *E. unio* by Survey entomologist G. L. Godfrey) were "eating" recently purchased lumber that had been stacked near his home.

Caterpillars and pupae of *E. unio* were found in dead stems of the soldier rosemallow (*Hibiscus militaris*) in Cleveland, Ohio, in 1868, according to the late C. V. Riley, internationally known entomologist. On October 13, 1983, Godfrey and his Survey colleague, D. J. Voegtlin, observed a similar situation in clumps of soldier rosemallow in Fayette County near Carlyle Lake, although living stems also were involved. By splitting the stems, they found eight pupal chambers, each within 25 cm of the stem base. Two chambers held *E. unio* which had not yet pupated, and the caterpillars which had been exposed began to construct new chambers on intact stem segments.

One caterpillar spent 11 hours and the other 12 in completing their new chambers, including the addition of "window dressing." Excavation commences with the caterpillar, head downward on the stem, biting a hole 4-5 mm wide (just large enough for passage of the caterpillar's head) in the stem and discarding the removed pieces of stem tissue onto the ground. This sounds simple. However, bear in mind that the caterpillar keeps biting, inwardly and obliquely downward for nearly its full body length, while intermittently ejecting stem material packed between its mandibles from the chamber without retreating from



Eudryas unio pupal chamber (left to right): a larva cutting the entrance hole (1 hour), wood chips being attached to the clear silk plug (10 hours later), a camouflaged plug (separate specimen), a split stem with the pupa in the chamber (the top chamber contains the puparia of a parasitic tachinid fly) (Photos by G. L. Godfrey).

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it. The head and part of the body fill the chamber during the biting process, but the caterpillar, with its flexible exoskeleton, has enough agility to loop itself sideways, bring its mandibles to the chamber's entrance, and shove out the scrapings with its hypopharynx ("tongue").

After approximately 9 hours of excavating, the caterpillar turns end for end. With its head now directed toward the entrance, the caterpillar spins a silk plug over the hole. The strands of silk coalesce and by themselves would form a transparent window, but during the 2- to 3-hour spinning process, small particles of stem are taken from the top of the chamber and attached to the inner surface of the plug to effectively conceal the entrance. Under natural conditions the caterpillar pupates within a week, and the resultant pupa is quite protected by its chamber through autumn, winter, and spring. The moth of *E. unio* escapes from the pupal case and breaks through the silk plug to emerge the following summer.

Recent Publications

Risser, P. G. 1984. Bibliography of Illinois Vegetation. Illinois Natural History Survey Biological Notes No. 121. 51 p.

Voegtlin, D. 1984. Notes on *Hyadapis foeniculi* and redescription of *Hyadaphis tataricae* (Homoptera: Aphididae). Great Lakes Entomologist 17(2):55-67.

Webb, D. W. 1984. A revision of the Nearctic species of the family Solvidae (Insecta: Diptera). American Entomological Society Transactions 110:245-293.

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The Biogeochemistry of North American Ungulates

In a study published in 1976, Harold C. Hanson of the Illinois Natural History Survey and Robert L. Jones, a soil mineralogist at the University of Illinois Department of Agronomy, reported on the relationships between minerals and soils and their absorption by plants, their consumption and absorption by geese, and the mineral levels found in feather keratin. Keratin essentially functions as a metabolic wastebasket for excess minerals. Insights into the progression of minerals through this segment of the ecosystem enabled these investigators to determine the birthplaces of wild geese. These findings have been shown to have immense practical application to the management of migratory birds, particularly waterfowl.

A spin-off of this study and of an evaluation of the role of sulfur in ecosystems was the realization that, despite many decades of study by big game specialists, the biogeochemical aspects of mineral licks of big game (ungulates) were poorly understood. Yet the dependence of ungulates, worldwide, on mineral licks for survival has probably been known since the time of early man. The failure in recent decades to arrive at a common denominator, or denominators, involved in mineral lick use was that each study had been confined to a small area. It became apparent that the phenomena would be subject to deciphering only if the use of mineral licks was studied comparatively against the whole spectrum of geologies on which the animals live.

To remedy this gap in the knowledge of ecosystems, Jones and Hanson solicited a continent-wide collection of earth materials from mineral licks to learn the chemical basis of the dependence of animals on earth supplements in their diets. The result of this endeavor is a book just published by Iowa State University Press — *Mineral Licks, Geophagy, and Biogeochemistry of North American Ungulates.*

Dall sheep at mineral lick somewhere in Alaska (Photo by Wayne Heimer).

The authors found that the primary reason that ungulates visit mineral licks is to avoid grass tetany — a convulsive condition that can lead to death resulting from the consumption of spring forages inordinately high in potassium and low in magnesium. As the plant matures or growth proceeds, there is a delayed or latent absorption of magnesium by the plant. This sequence of events has been shown to be

exhibited in the hair of moose. These relationships have overriding significance, as both magnesium and calcium are required for the normal transmission of nerve impulses and muscular responses.

Licks high in sodium or magnesium and/or calcium solve the seasonal mineral imbalance for plant consumers — sodium by its reciprocal effect in reducing potassium levels and magnesium by compensating for losses of this latter mineral caused by an increase of the hormone aldosterone from the adrenal cortex. Concomitantly, increased sodium intake probably aids in more efficient absorption of magnesium — thus having a dual effect in correcting mineral imbalances resulting from high potassium intake.

The results of mineral lick analyses and the line of reasoning developed in this study have been applied to the understanding of two age-old riddles — the 4-year cycles in rodents, particularly the microtines (meadow mice and lemmings), and the 10- to 11-year cycle of abundance in snowshoe hares. The die-off of lemmings has been associated in spring with convulsive conditions — both in Norway and Alaska. In snowshoe hares, the die-off at population peaks has been called a response to "shock disease" or hypoglycemia — basically a low blood sugar condition. But magnesium is a required co-factor for 8 of the 13 enzymatic steps in the glycolysis, or the metabolism, of blood sugars. Readily drawn upon magnesium reserves in animals have very narrow limits. Thus, this factor, coupled with possible cyclic lows of magnesium in woody plant foods and in geologic substrates and soils low in magnesium, sets the stage for die-offs precipitated by mineral imbalances.

Insect Resistance in Soybean Pest Management

An insect-resistant variety of a crop plant is one that possesses some biochemical or morphological trait which allows it to avoid, tolerate, or recover from insect injury. If possession of these traits prevents a particular insect species from reaching damaging population levels, the use of such varieties becomes a very powerful pest management tool. For example, the erect hairs along the stems and leaves of most soybean varieties have virtually eliminated the potato leafhopper (a tiny sucking insect) as a potentially serious pest of this crop. This simple morphological trait of most commercially grown soybean varieties presents an effective barrier to feeding and egg laying by this highly mobile, abundant insect pest.

Erect hairs along stems and leaves of most commercial soybean varieties interfere with potato leafhopper feeding (Photo by Y. I. Lee).

Since 1970, entomologists, plant physiologists, and biochemists at the Illinois Natural History Survey and plant breeders and geneticists at the United States Department of Agriculture Soybean Laboratory on the University of Illinois campus have teamed their efforts to better understand the insect host-selection process and the physiology of resistance within the soybean crop. This program in host-plant resistance has two main components: (1) breeding soybean plants for improved resistance to defoliators and (2) studying the mechanisms of resistance.

Within the breeding portion of the program, Survey entomologists routinely screen as many plant introductions, breeding lines, and varieties from the germ plasm collection as possible. During 1984 alone, over 370 breeding lines were evaluated in the field and in laboratory choice tests for resistance to insect feeding. Through the course of this research, thousands of soybean lines have been screened, and numerous varieties have shown measurable

levels of resistance to one or more insect pests. A primary goal of the Illinois breeding program has been to transfer desirable resistance factors into agronomically acceptable varieties. Using plant introductions numbered 171451 and 229358 as sources of resistance (previously identified in South Carolina as highly resistant to the Mexican bean beetle), five promising soybean lines have been developed and released for public use in additional breeding programs.

Efforts to better understand the exact mechanisms of the resistance phenomenon in the soybean crop must deal not only with the morphological and biochemical differences between resistant and susceptible varieties, but also with the way in which the insect perceives them. In-depth plant-chemical profiles of resistant and susceptible lines are being compiled in an attempt to detect subtle differences which may explain the insect response to a given food plant. Additionally, detailed morphological and electrophysiological studies of insect sensory structures are under way, and these may help to explain exactly where and how an insect makes the decision to accept or reject a soybean line as a suitable host.

Unlike the example of leaf hairiness and the potato leafhopper, the causes of most insect resistance in crop plants are likely to be complex and very seldom due to a single trait or chemical. Progress toward the development of agronomically acceptable, insect-resistant soybean cultivars has been painstakingly slow. However, given the complexity of the host-plant selection process and the difficult genetic manipulations required in the breeding program, this time frame for the development and release of insect-resistant soybean varieties is not abnormal.

Nevertheless, host-plant resistance has tremendous potential for future use in successful integrated pest management programs. Resistant varieties are highly compatible with existing management strategies, should lower production costs, and should reduce or even eliminate the need for insecticide applications, thereby improving the quality of our environment. Continued emphasis on the development and understanding of insect resistance in soybeans by this multidisciplinary team should result in insect-resistant varieties becoming a major component of pest management systems for Illinois soybean producers.

Survival Rates in Squirrels

Gray and fox squirrels are among the most popular small game animals in Illinois, with annual harvests exceeding 1 million. Unfortunately, information from unexploited fox squirrel populations, which could be used to aid in the understanding of fox squirrel population fluctuations and the establishment of harvest regulations, has not been available.

Wildlife ecologists Charles Nixon, Lonnie Hansen, and Stephen Havera studied an unhunted fox squirrel population for 7 years to answer questions about the demography of squirrels. These answers will be pertinent to management practices. One of the most important questions investigated involved survival rates and factors affecting survival rates in natural populations of fox squirrels.

Longevity of male and female squirrels

Young fox squirrels nesting in wood duck box (Photo by W. E. Clark).

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was found to be similar but squirrels 1 year and older when first captured lived on the study area much longer than those less than 1 year old when first captured. These differences likely reflected not only higher mortality rates of young squirrels, but also a greater tendency of young to scatter from the study area. Surprisingly, fox squirrel survival was not correlated with production of tree seeds, as has been found by researchers studying gray squirrels. This lack of correlation may be attributed to the abundance of tree seeds during the 7-year study, the varied diet of the fox squirrel compared with that of the gray squirrel, and the tendency of fox squirrels to use agricultural crops. Severity of winter weather, as indicated by snowfall and temperature deviations from normal, also did not appear to affect recapture rates.

Recapture rates of subadult and adult immigrant squirrels were negatively correlated with densities of adult females. Survival of resident squirrels was not affected by adult densities. These results suggest that social conditions initiated by the adult female may limit the number of new squirrels recruited into the population. Maximum densities of fox squirrels within a forest, therefore, could be limited in this way.

These results have important management implications because they suggest that attempts to increase squirrel densities artificially, for example, by releases, would likely fail if a resident squirrel population were present. Detailed experimental studies of fox squirrels are currently being performed to substantiate the role of adults in density regulation and to evaluate the effects of exploitation on fox squirrel demography.

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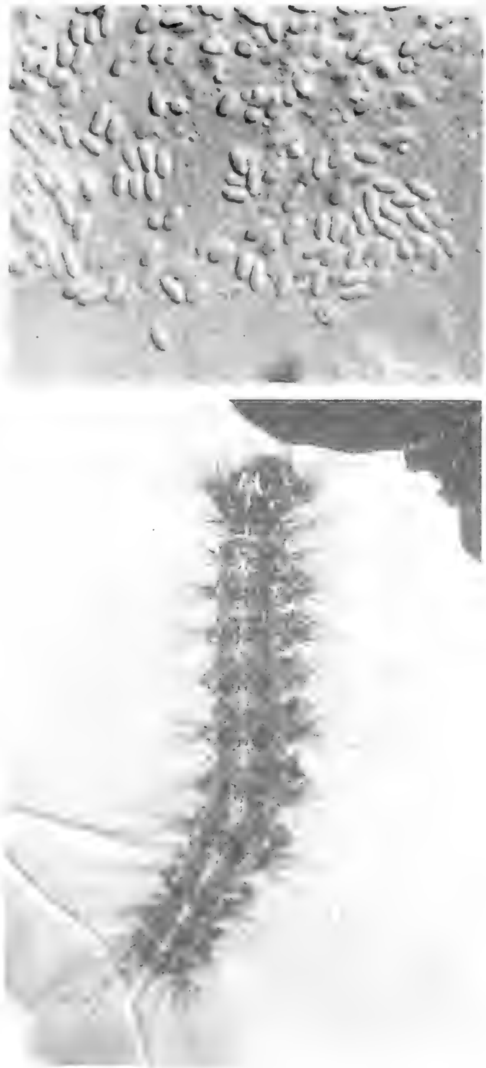
Scientists Seek Biological Control of Gypsy Moth

As part of a cooperative agreement with the U.S. Forest Service, Survey entomologists Joseph Maddox and Michael Jeffords will travel to Europe this spring to collect microscopic, single-celled organisms called microsporidia from gypsy moth populations. These pathogens, disease-producing organisms, will be tested, both in the laboratory and in a greenhouse model forest ecosystem, for their potential as biological control agents of the gypsy moth and for their environmental safety. Maddox and Jeffords hope to find one or more promising species to introduce into North American gypsy moth populations as permanent mortality factors. If these efforts prove successful, it will be the first time that a classical biological control program involving a pathogen will have been conducted against the gypsy moth.

Many insects that have attained pest status in the United States, including the gypsy moth and European corn borer, are not native species but were introduced from other countries. When an imported insect encounters a new environment with suitable weather conditions and abundant food, it often undergoes an explosive population increase because it has been introduced *without* its natural enemies — organisms that use the insect as a food resource. Natural enemies, including predators, parasites, and pathogens, are extremely important in keeping insect populations in check.

Biological control is the planned relocation of natural enemies from one place to another. The objective of classical biological control is to find the most effective



Microsporidian pathogens collected in Europe will be studied for their potential as biological control agents of the gypsy moth in North America. **Top:** Spores of a microsporidium in the genus *Nosema* — actual length 5 microns (Photo by J. V. Maddox). **Bottom:** Mature larva of the gypsy moth, *Lymantria dispar* — actual length about 2 inches (Photo by J. E. Appleby).

natural enemy species and to colonize them in the new environment of the pest insect. The first successful biological control in the United States took place in 1888 when the predaceous vedalia beetle was imported from Australia to control the devastating cottony cushion scale. The fledgling citrus industry in southern California was saved, which generated a great deal of enthusiasm for this control strategy. Many successful introductions of natural enemies followed.

The United States Department of Agriculture first became involved in the biological control of pest insects in 1905 by importing natural enemies of the gypsy moth. The gypsy moth was brought from Europe to Massachusetts in 1869 by Leopold Trouvelot, who had planned to breed it with the silkworm to produce a better silk-making caterpillar. Several gypsy moths escaped during the course of his experiments, and within a few years populations were high enough to cause noticeable defoliation of trees in the area. Since its inception, the U.S.D.A. gypsy moth natural enemy introduction program has resulted in the establishment of one predator species and ten species of parasites imported from Europe and Asia. Although the combined mortality inflicted by these imported species can be significant, the gypsy moth continues to reach outbreak levels, especially in newly invaded parts of its range. In 1981, one of the worst gypsy moth outbreaks to date occurred: 13 million acres of trees were defoliated and damage was $764 million nationwide.

Researchers are beginning to find that pathogens are often the most important mortality factors affecting forest insect populations. While most classical biological control work has involved introductions of parasites and predators, success has been achieved in Canada by using imported viruses to control forest insect pests. In the United States only one pathogen, a nucleopolyhedrosis virus (NPV), causes significant gypsy moth mortality. Gypsy moths in Europe, however, are infected by a number of other pathogens in addition to the NPV, including microsporidia. High levels of microsporidian infection have been implicated in the collapse of gypsy moth populations, and if Maddox and Jeffords find the right ones, control of the gypsy moth may improve greatly.

Supplement to *Aquatic Oligochaeta of the World* is Published

Oligochaete! Thou taxonomic pain!
My mouth and mind and memory affirm,
'Twould be much less a stress upon the brain
To designate you merely as a worm.
But then again, perhaps it is untrue
To brand you as too simple for your name.
For possibly, the tests we put you through
Just don't quite fit your undulating frame.
Psychologists are on the highest ground
When studying the ways of mice and men.
But with invertebrates they're often found
Quite ignorant of how they should begin.
The object of my study is to try
To help both man and worm see eye to eye.

— D.N. Howell (1974)

Earthworms are familiar enough to anyone who has worked with soil or gone fishing. More than 80 percent are close relatives of the common garden earthworm. Several families of worms are entirely aquatic, while other families which are primarily terrestrial have one or more genera inhabiting aquatic or semiaquatic habitats. In December 1984, Dr. Ralph O. Brinkhurst of the Institute of Ocean Sciences in Sidney, British Columbia, and Mark J. Wetzel of the Section of Faunistic Surveys and Insect Identification, published a paper entitled *Aquatic Oligochaeta of the World: Supplement. A Catalogue of New Freshwater Species, Descriptions, and Revisions.*

This contribution provides an annotated list of freshwater oligochaete genera and species described or revised since the global review of the literature on this subject by the senior author and B. G. M. Jamieson

in 1971. The intent of the authors was not to provide a formal taxonomic revision based on the examination of old and new material, but rather to organize and present recent published information so that such revisions by subsequent authors might be completed more efficiently. This compilation should be particularly useful to authors wishing to publish species descriptions, revise copies of regional keys, or recognize synonyms employed in the wider, nontaxonomic literature. Discussions of major diagnostic characters of new taxa, possible synonyms suggested by the literature, and transfers of species between genera which result in several new combinations are presented.

The most significant change in oligochaeta systematics since 1971 has been the recognition of intraspecific variation and environmental modification of setae, or hairs, resulting in the synonymization of some species. The authors report on several research programs which question the prior heavy reliance on setal form for generic decisions, even in the presence of other distinguishing characteristics. Increasingly refined research being conducted on oligochaete systematics has suggested that the issue is really one of intraspecific variation in any character. Other research programs have demonstrated that some setal forms reflect a degree of development rather than the presence or absence of certain characters, as described in most species definitions. The authors suggest that such fine differences between species within certain families of worms, established by the typological method, may have little practical value for ecologists; the resolution of this issue depends on an increase in the amounts of field work on these families, which has just begun.

Lead Poisoning in Illinois Waterfowl

Ducks, geese, and other birds become exposed to lead poisoning when they ingest lead shotgun pellets that have been deposited in waterfowl habitat as a result of sport hunting. The pellets are retained in the gizzard, where the lead is gradually dissolved and then absorbed by blood and subsequently by other body tissues. In ad-

Dr. Frank Bellrose, nationally known wildlife specialist who recently retired from the Survey's Havana field station, retrieving dead ducks that ingested lead shot at Rice Lake, near Banner, Illinois.

dition to contaminating the bird's blood, liver, and kidneys, lead also enters the brain. Such contaminated birds often die. In fact, in his definitive study of lead poisoning, Survey researcher Frank C. Bellrose estimated in 1959 that 2-3 percent of the entire North American waterfowl population succumb to this disease annually. With today's populations, this means a loss of 1.6-2.4 million birds each year.

Illinois Department of Conservation biologist William L. Anderson and Survey researcher Stephen P. Havera recently investigated the extent and severity of lead poisoning among waterfowl in Illinois. In a sample of 13,246 gizzards from mallards harvested on 55 areas from 1979 through 1983, 5.9 percent contained one or more ingested pellets. Ingested pellets were found in gizzards from virtually all areas, revealing that lead poisoning occurs throughout the state. Incidences of ingested pellets in mallard gizzards exceeding 10 percent occurred in several areas in some years, and the astounding rate of 20 percent, or one out of every five gizzards, was evident on occasion. For lesser scaup, more popularly called "bluebills," the incidence of ingested pellets in 753 gizzards was 3.2 percent. In a sample of 526 Canada geese, the incidence was 4.2 percent.

When it is recognized that these ingestion rates represent merely "still images" of a dynamic process in which lead pellets are continuously being ingested and dis-

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solved (in about 3 weeks), it is evident that 20-30 percent of Illinois' waterfowl population is contaminated with lead each year. Incorporate into this calculation the fact that several million ducks and geese migrate through or winter in Illinois annually, and the number of individual waterfowl that contract lead poisoning in our state becomes excessive.

Anderson and Havera extended their investigations of lead poisoning by collecting blood samples of 2,265 waterfowl captured on seven areas during the fall and winter periods of 1980-1981 through 1982-1983. These blood samples were analyzed for concentrations of lead and protoporphyrin. Protoporphyrin is a precursor to hemoglobin, and it increases as a response to lead poisoning in ducks and geese. The rates of lead poisoning indicated by elevated protoporphyrin in blood were equal to or greater than those suggested by ingested pellets in gizzards. Moreover, lead poisoning as revealed by elevated lead in blood was about twice as great as the rates indicated by elevated protoporphyrin levels and ingested pellets. It was evident that lead in blood was the most sensitive technique for detecting lead poisoning in waterfowl, protoporphyrin in blood was intermediate, and ingested pellets in gizzards was the least sensitive. Anderson and Havera concluded that the incidence of ingested pellets in gizzards provided conservative estimates of the severity of lead poisoning in Illinois' wild waterfowl populations. Thus, lead poisoning of waterfowl in Illinois is probably more serious than originally predicted.

Research has shown that the ingestion of a single lead pellet by a duck always results in lead contaminating the blood, liver, kidneys, and brain. The very least consequence of waterfowl ingesting lead is the inhibition of enzyme activity in these vital body tissues, and, at least in the brain, cellular damage occurs. The brain damage is irreversible, and without question places the bird at a disadvantage in attempting to survive, migrate, and reproduce in the wild. The other possibility is death as the result of acute lead poisoning. The loss of thousands of waterfowl throughout the United States to lead poisoning each year can be eliminated by the conversion to nontoxic steel shot for use in the sport hunting of ducks and geese.

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Frank Bellrose Receives Aldo Leopold Medal

FRANK BELLROSE

Frank Bellrose, former wildlife specialist at the Survey, was presented the Aldo Leopold Memorial Medal for his distinguished service to wildlife conservation at the 50th Anniversary meeting of The Wildlife Society in Washington, D.C. recently. The award is the ultimate recognition of a wildlife professional and Bellrose is the first Illinoisan to receive it.

The dedication and deep convictions of this scientist have led to a better understanding of wetland resources. He has long been concerned with the wildlife trends and problems along the Illinois and Mississippi flyways. The first scientist to report the poisoning of countless waterfowl by lead shot, he is closely associated with excellence in waterfowl research and management and is widely regarded as "Mr. Waterfowl."

Over 90 publications are credited to his work and consist of a wide variety of topics ranging from waterfowl food plants, to muskrats, to waterfowl migration corridors. One of his most notable contributions is associated with the rewriting and revision of the *Ducks, Geese, and Swans of North America*. This book has been recognized as one of the most complete waterfowl references in print.

He has received numerous honors and awards, including The Wildlife Society Publication Award, the Oak Leaf Award from the Nature Conservancy, American Motors Conservation Award, and the National Wildlife Federation Conservation Award. He is a Fellow of the American Ornithologists' Union, an honorary life member of The Wildlife Society, and recipient of an Honorary Doctor of Science degree from Western Illinois University.

The 1985 honoree was born in Ottawa in 1916, and completed his academic training in Zoology at the University of Illinois. His wildlife career began with the Illinois Natural History Survey in 1938 as an Assistant Game Technician. He progressed to Assistant Game Specialist in 1945; to Wildlife Specialist in 1955; and to Principal Scientist with the Survey in 1981. Since 1963, he has been an Adjunct Professor and Research Associate at Western Illinois University.

Bellrose retired from the Survey in 1983, but he continues to work almost daily at the Havana Laboratory or in the field.

Sapsuckers Damage Trees

Sapsucker damage is caused by a bird known as the yellow-bellied sapsucker, a member of the woodpecker family. The damage caused by the sapsucker is primarily done in early spring when the bird migrates back from its winter environment. Small, closely spaced holes formed in regular rows around the trunk and branches can be found on pine, birch, maple, linden, and other tree species that "bleed" freely from bark wounds. The "drilled" holes made by the sapsucker extend into the wood and usually completely encircle the stem and branches, and are the result of the natural feeding habit of the bird. The bird is one of the smaller woodpeckers, having black and white plumage, a wide white stripe on the wings, a red patch on the forehead, and a yellowish breast.

Unlike most members of the woodpecker family, sapsuckers rarely drill into the bark to search for insects, but do drill holes in the bark of healthy trees to obtain tree sap on which they feed as it seeps from these bark wounds. It is believed that half of the food material sapsuckers consume, at least in early spring, is composed of sap and of the insects that are attracted to tree sap. Some of their other foods are small fruits and insects they catch on the bark. Hummingbirds also visit rows of sapsucker holes to feed on the sap and insects.

Because several rings of holes are frequently made, and because trees may be injured several years in a row, the bark can be riddled with wounds that cause severe reduction of the normal transport of sugars down to the root system. Also, the outer wood is damaged and water and nutrient transport to the crown is greatly reduced. When several bands of holes extend around the branch or trunk, the top of the tree may die. Sometimes on smaller trees a bulge will develop above the ring of holes indicating a backup of sugar transport through the inner bark.

In areas of high sapsucker migration, many Scotch pine and sugar maple trees will exhibit injury made over a period of several years. Towns in agricultural areas, such as east central Illinois, tend to attract many sapsuckers because there are so few

The branch sections pictured were cut from Scotch pines that were fed on heavily by sapsuckers. After one to two years, sapsucker wounds will develop as square or rectangular holes in the bark as a result of further tree growth.

trees in the region. In addition, many of the trees that have been planted as ornamental shade trees are among the favorites of the sapsucker. Frequently, one tree will be singled out for heavy feeding. Because the birds are shy creatures, they are easily disturbed by humans, are observed infrequently, and are seldom seen or heard when they drill holes in the trees on which they feed.

Sticky, bird-repellent materials applied to the trunk have not been successful in repelling sapsuckers, and they are impractical to apply to large areas of a tree trunk. Strips of shiny aluminum foil that will flutter in the wind and are attached by string to a few branches may help to frighten the birds away. No other procedures are known that have been successful repellents. Injured trees will be helped in recovering from sapsucker injury if they are fertilized in the spring or early summer, and watered during the dry periods of the summer.

Survey Investigates Fruit Crop Pest

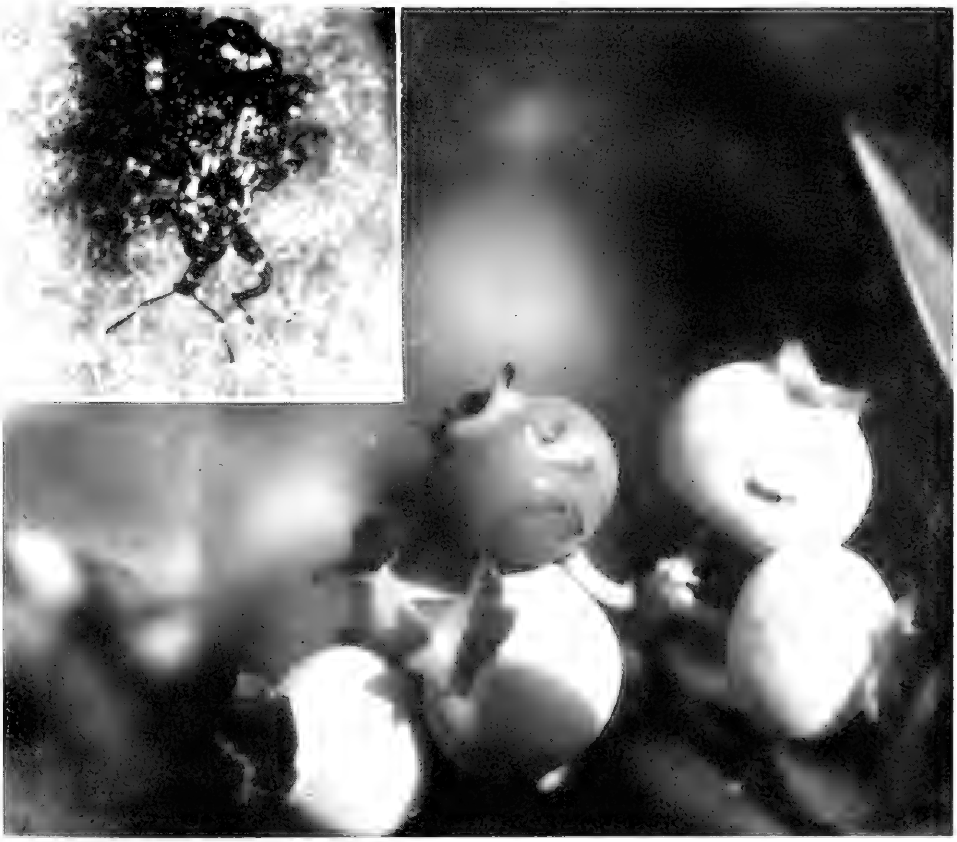
The plum curculio, *Conotrachelus nenuphar* (Herbst), feeds on many fruit crops

east of the Rocky Mountains, including apple, apricot, blueberry, cherry, nectarine, peach, and plum. Adults feed on green fruit in the spring, and sometimes on ripening fruit in the fall. Females make crescent-shaped incisions on the fruit, laying a single egg in each incision. The developing larva feeds inside the fruit, and may cause premature fruit drop.

Less is known about the plum curculio than any other key pest of stone or pome fruit. Scientists have been unable to predict exactly when plum curculio will first appear on fruit crops in the spring. As a result, growers are forced to apply several insecticide treatments to ensure that at least one application will be on time to prevent plum curculio damage.

Milt McGiffen, an Assistant Supportive Scientist in Economic Entomology, found that insecticide usage could be greatly reduced if sprays were precisely timed. While working with John Meyer at North Carolina State University, McGiffen examined the effect of environmental factors on overwintering behavior and spring migration in plum curculio, hoping to find a key to the accurate prediction of the spring appearance of *C. nenuphar* on fruit crops. He concluded that the return of plum curculio to their host plants is the result of two events in the insect's life cycle, diapause termination and postdiapause migration.

Diapause is a state of suppressed development similar to hibernation. Respiration rate, characteristically low during diapause, may be used as an assay for the physiological changes associated with overwintering. With the aid of a gas chromatographic technique developed by a fellow graduate student, Jack Boyne, McGiffen used the respiration rate to determine when diapause ends in plum curculio. He



(Upper left) Plum curculio rests on the fuzzy surface of a peach. (Lower right) Adult curculio make crescent-shaped incisions on fruit. The developing larvae feed inside the fruit and may cause premature fruit drop.

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found that diapause termination (the physiological processes involved in completing diapause) is completed before winter ends, and thus does not determine when spring migration is initiated. Low temperatures act to suppress activity and conserve energy during the transition from diapause to reproduction, a life stage called postdiapause development.

Plum curculio is vulnerable to starvation if sustained periods of warm temperatures occur during postdiapause development. However, most overwintering plum curculio do not initiate migration to food plants until the temperature reaches 60°F (to warm flight muscles) and relative humidity exceeds 50 percent (plum curculio are sensitive to desiccation or drying out). Further, deaths due to the insect disease, *Beuvaria bassiana* (Balsamo) Vuillemin, increase rapidly as temperature rises.

The impact of these factors on plum curculio populations may be severe during certain situations. If spring weather is warm and dry or fruiting of host plants is not synchronized with migration, plum curculio populations may suffer high mortality rates. From an evolutionary standpoint, the plum curculio's dependence on temperature and humidity as signals to initiate migration are understandable; spring is usually humid, and host fruit availability is dependent upon temperature.

Because of these findings, it was concluded that the timing of plum curculio migration from overwintering sites to host plants is critical in predicting when the pest first appears on fruit crops. A simple model of the relationship between plum curculio flight initiation and ambient temperature and humidity was developed. Researchers hope the model's predictions will allow more precise timing of insecticide applications, and thus lead to better control practices for this serious pest.

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Endangered Illinois Fishes

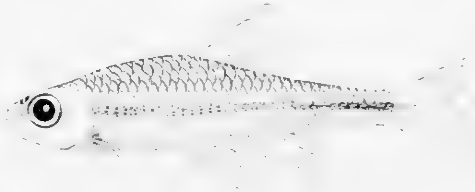
A large number of fishes have disappeared from Illinois within historical time, and several more are on the verge of extinction. Already gone from Illinois are the Ohio lamprey, blackfin cisco, longjaw cisco, rosefin shiner, greater redhorse, gilt darter, stargazing darter, crystal darter, and native populations of the muskellunge. On the verge of extinction are several other fishes, the more critical of which are the lake sturgeon, alligator gar, cypress minnow, bigeye chub, bluehead shiner, pugnose shiner, blacknose shiner, northern madtom, and harlequin darter.

For some species nearing extinction in Illinois, the problem seems to be an inability to adjust to pervasive aspects of environmental degradation (e.g., stream siltation) over a large area of the state, and it may not be possible to prevent the loss of these species. An example is the bigeye chub, which once ranged over much of eastern and southern Illinois but now is found in only a few small streams. For other species, the protection of critical habitat could save the Illinois populations. Among the most endangered fishes in Illinois are six species which appear to fall into the latter category: the cypress minnow, pugnose shiner, bluehead shiner, northern madtom, bluebreast darter, and harlequin darter. Each is confined to a small area of Illinois and appears to be endangered because its population is small and vulnerable even to minor modifications of its habitat.

A study designed to locate the largest Illinois populations of three endangered fishes, the pugnose shiner, bluehead shiner, and harlequin darter, and to identify characteristics of the habitat most critical to their survival, was initiated by Survey scientists L. M. Page and K. S. Cummings. These three fishes were selected because they are considered extremely endangered in Illinois, and protective measures must be taken quickly if Illinois populations are to survive. Fortunately, all occur in areas and habitats amenable to protection. With partial funding by the Illinois Department of Conservation, field work began in July 1984 and should be completed by the fall of 1985.

The pugnose shiner has been referred to as one of the rarest minnows in North America, and one which is undergoing an alarming decline throughout its range. Its decline seems to be related to increased turbidity and the concomitant loss of aquatic vegetation. It has disappeared from the state of Ohio, is considered threatened with extinction in Wisconsin, and is extremely rare in Minnesota, Indiana, and New York.

In Illinois, the pugnose shiner is one of the rarest fishes. Originally described in 1885 from Fox River in McHenry County,



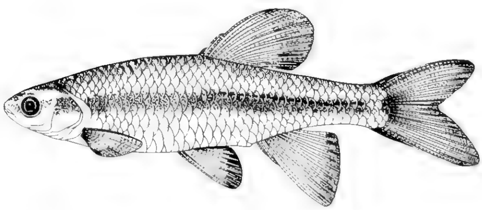
Pugnose Shiner (Drawing by Craig Ronto).

Illinois, the species was found in Fourth Lake in Lake County in 1892 and in a floodplain lake of the Illinois River in Mason County in 1909. Additional observations of the pugnose shiner (all in Lake County) were made in Channel Lake in

1965, and Loon Lake and Grass Lake in 1968. No observations of the pugnose shiner in Illinois were made between 1968 and 1984 and it was believed that it might already have disappeared from the state.

Nearly all of the natural lakes in northeastern Illinois, where most of the pugnose shiners have been found, now are surrounded by human dwellings and receive ever-increasing amounts of pollution. Many have had deliberate introductions of sport fishes, all of which are highly predatory and are known to alter the natural balance in predator-prey relationships. However, some lakes appear to remain in a sufficiently natural condition to support the pugnose shiner.

The bluehead shiner has a highly disjunct range, with the Illinois population being the only one found east of the Mississippi River and is far to the northeast of any other known population. In Illinois, it has been found only in Wolf Lake and in the contiguous LaRue Swamp, in Union County. It was first discovered in Wolf Lake in the mid-1950's and last observed there in 1974. Several recent attempts to document its continued presence have been unsuccessful, but Wolf Lake is an extremely difficult place to sample, and the species may still be present. LaRue Swamp



Bluehead Shiner

has been sampled many times in recent years, but the bluehead shiner has not been found, and its earlier presence there is assumed to have represented stragglers from Wolf Lake.

Wolf Lake is an old, deep, mud-bottomed oxbow of the Big Muddy River, margined with emergent and submerged vegetation. Elsewhere the species occupies similar lakes and backwaters of sluggish small- to medium-sized streams. Usually the habitat is heavily vegetated and has a bottom of mud or sand. Other populations of the bluehead shiner are known in Arkansas, Louisiana, and Texas.

The harlequin darter also has a highly disjunct range. The Illinois population, now apparently confined to the Embarras River (and possibly the Wabash River), is a relict of a more widespread population. No harlequin darters have been found in Indiana since 1890, and a similarly disjunct population in the Patoka River in Indiana now may be extinct.

The harlequin darter was discovered in the Embarras River in 1964, and a few specimens were found at several sites in

Harlequin Darter

Cumberland and Jasper counties between 1964 and 1968. It was not seen again in Illinois until 1983 when one was found in the Embarras River below the Charleston Dam in Coles County.

Harlequin darters live in rocky riffles and accumulations of leaves and debris over sand or gravel in runs of small- to medium-sized rivers and large creeks. The species is found sporadically from the Wabash River system in Illinois and perhaps Indiana, south in tributaries of the lower Mississippi River to Louisiana, and in Gulf Coast drainages from the Escambia River in Florida to the Neches River in Texas. The species seldom is common anywhere.

Although the Embarras River has been dammed at Charleston, channelized in its lower reaches, and suffers from siltation, the stretch of the river from Charleston to Newton retains an excellent variety of habitats and supports large populations of many fishes. The 1983 observation of a harlequin darter in the river attests to the possibility of protecting the Illinois population by protecting the river.

All localities in Illinois at which these

three species are known to have occurred will be revisited in 1984-1985. Additional localities in Illinois which are within the geographic domain of the species and appear to have suitable habitat will be sampled also. Included in the results of the study will be an assessment of the status (i.e., distribution and abundance) of each of the three species in Illinois, a description (based on observations and published information) of the ecological requirements important for survival of the species, an assessment of the causes for the decline of the species in Illinois, and identification of habitats in Illinois critical to the continued survival of the species.

Field work to date has located a population of the pugnose shiner in East Loon Lake in Lake County, and confirmed the continued existence of the harlequin darter in the Embarras River below Charleston Dam in Coles County. Researchers have been unable to locate bluehead shiners in Illinois; however, a search for this species in Horseshoe Lake in Alexander County, a lake similar in many respects to Wolf Lake, produced a cypress minnow, a species not seen in Illinois since 1940 and thought to have been extirpated from the state.

[Fish drawings were taken from *Fishes of Illinois* by Philip W. Smith.]

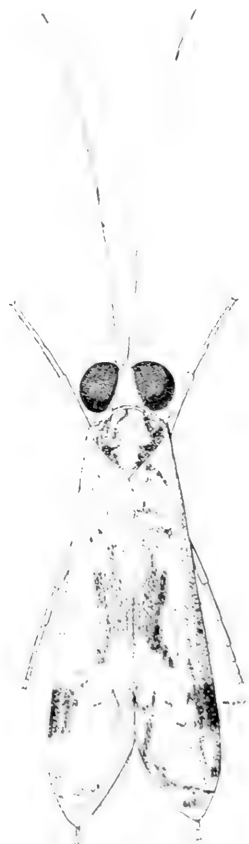
Caddisfly Systematics

The caddisflies comprise the insect order Trichoptera, containing nearly 10,000 species worldwide grouped in several hundred genera and approximately 35 families. Caddisflies are aquatic insects which live in lakes and streams. Survey entomologist J. D. Unzicker has been studying the systematics of the family Hydropsychidae, which occurs throughout the world.

Hydropsychid caddisflies are known as net-spinners because the immature stage or larva constructs a silken net or retreat to filter microscopic articles of food from moving water. Caddisflies are an integral and important part of the aquatic food chain in Illinois' streams and lakes.

Until recently hydropsychid genera have been diagnosed to a large extent on the basis of structures of the adult stage. Unzicker and a Canadian colleague have analyzed the 20 North American species of the genus *Symphitopsyche* using both adult and larval structures. Closely related species were clustered first on larval and then adult characters, and then the two sets of species groupings were compared. There was almost complete overlap of the clusters based on characters of two different life stages. This method provides a high degree of confidence in the characters selected as diagnostic for a genus in the Hydropsychidae.

Unzicker has already published a new alignment of eight North American genera in the subfamily Hydropsychinae, but an important problem remains to be solved. How do these eight genera fit with the 22 other genera occurring on other continents? He is now examining these 22 genera in the subfamily in order to find structures



Adult net-spinning caddisfly of the genus *Hydropsyche* (Drawing from *Caddisflies of Illinois* by Herbert Ross).

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in both the adult and larval stages which will be diagnostic for each genus. The combination of adult and larval characters provides valuable evidence for inferring psylogeny (i.e., history of the lines of evolution) and, if this is known, their diverse distributions should make possible the inference of past dispersal routes which have led to present day distributions of these genera. Unraveling the relationships of the many genera in the family Hydropsychidae is the goal of Unzicker's research.

The INHS/IDOT Program

The Natural History Survey has assisted the Illinois Department of Transportation (IDOT) for several years by conducting faunal and floral inventories and surveys of endangered and threatened species and natural areas likely to be affected by highway and bridge construction, replacement, or repair activities. A typical year has required 25 to 30 detailed studies, each needing from several days to months of investigation and research.

The Survey's program with IDOT was expanded in scope and number of studies to be conducted for fiscal year '85 to include two additional areas of responsibility. In the first, Survey scientists are mapping and evaluating soils, and determining the presence, characteristics, and extent of prime farmland and wetlands for each of 400 to 500 new highway projects per year. Scientists are also providing a preliminary screening of the biological resources to assess the need for additional study.

Recommendations for additional research are one source of detailed studies such as those performed in the original program. Also, projects occasionally require extensive investigation by a diverse research team (such as the detailed botanical, zoological, water quality, and soils research performed at the Morton Arboretum). Such "special projects" are covered in the second new area of the INHS/IDOT program, established to coordinate these extended studies.

Ten new Survey positions were created for this expanded program and are funded by contract from IDOT. These include: biology assistants (2), botanists (2), soil scientist (1), soil mappers (2), biologist/coordinator (2), and an administrative assistant (1). Warren U. Brigham serves as Director of the INHS/IDOT program. Project coordinators are Allison R. Brigham, screening studies; Gene Ardner, detailed studies; and Mark J. Wetzel, extended studies. Most of the staff and workload for this expanded program is in the Section of Faunistic Surveys and Insect Identification, with support from the Section of Botany and Plant Pathology.

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An Epizootic in the Alfalfa?

Epizootiology, or the study of disease dynamics in insect populations, is a relatively new area of research. Three major factors are important in the development of epizootics, or epidemics: (1) a pathogen, or infectious agent; (2) a group of susceptible insect hosts; and (3) an effective method of disease transmission among hosts. The ecology of epizootics, and the environmental factors that affect their development, are important areas of research.

Economic Entomology staff members Marilyn Morris and Michael McGuire are currently studying fungal pathogens of the alfalfa weevil and the potato leafhopper, two major pests of alfalfa in Illinois. Certain factors limit the effectiveness of each pathogen in controlling pest populations, and neither pathogen is part of an existing Illinois pest management program for alfalfa.

In the case of the alfalfa weevil pathogen, *Erynia phytonomi,* disease epizootics have been observed routinely since the late 1970's. The epizootics, however, often occur too late in the season to keep the weevil population below a crop-damaging level, so that chemical sprays are needed. This late occurrence is characteristic of many fungal pathogens and can limit their pest-controlling capabilities. One management strategy that could increase the effectiveness of this pathogen is to cause the disease to begin earlier in the growing season. Disease activity typically begins when over-wintering resting spores germinate in the spring and begin the infection cycle in the host population. Genetic selection for earlier resting spore germination could increase the effectiveness of epizootics. Unfortunately, the field conditions that promote resting spore germination are poorly known. Survey researchers are examining the possible influences of temperature and photoperiod on germination.

Another method of inducing early disease onset is to "seed" fields with cultures of the actively growing fungus early in the season. Conidiospores, released by the cultures and responsible for the spread of infection among insects, would infect susceptible hosts, allowing the disease to become established in the insect population earlier than usual. This method could also be used to establish the pathogen in an area where it does not exist. Using this method, an attempt was made to establish the potato leafhopper fungus, *Erynia radicans,* in Illinois. While this fungus is present in Wisconsin, it has never been found in Illinois. Sporulating cultures of *E. radicans* were introduced into potato fields where uninfected potato leafhoppers were present. Although cultures produced many spores, subsequent sampling yielded only a few

Healthy alfalfa weevil larvae and larvae infected with the pathogenic fungus, *Erynia phytonomi* (Photo by Marilyn Morris).

infected leafhoppers and the infection soon disappeared from the field.

The failure of *E. radicans* to become established may be due to adverse environmental conditions. Environmental factors play a very important role in the development of epizootics and can limit or enhance the growth and spread of pathogens. For fungal diseases, high humidity is considered to be among the most important requirements for spore formation and germination. If humidity is adequate, temperature may be a limiting factor. Growth studies have shown that *E. radicans* grows poorly, or not at all, at the high temperatures common during the midsummer in Illinois alfalfa fields, when potato leafhoppers are abundant. The inability to develop at high temperatures may explain why the introduction of the pathogen into Illinois fields was unsuccessful. The selection and subsequent introduction of fungal strains that can grow and infect leafhoppers at higher temperatures may facilitate the use of this fungus for biological control. *E. phytonomi,* the alfalfa weevil fungus, also grows poorly at high temperatures. However, the susceptible stage of the weevil is present in Illinois in late spring, and the typically cool temperatures at that time allow for fungal growth and the observed epizootics.

In addition to initial infections and favorable environmental conditions, a threshold population of susceptible hosts and an efficient means of disease transmission are also needed for an epizootic to develop. For the alfalfa weevil and its associated fungus, *E. phytonomi,* approximately two weevils per alfalfa stem must be present before an epizootic will develop. This population level is very close to the weevil density above which insecticidal spray treatments are applied. In order to avoid the use of chemical sprays and maximize the role of the pathogen for insect control, certain agricultural cropping methods that increase the transmission efficiency of the fungus can be employed. An early first harvest of alfalfa, timed to coincide with the first incidence of diseased larvae could concentrate weevil larvae on the stubble and, by removing the alfalfa foliage, allow the airborne spores to spread more readily to the remaining weevil population.

Before either of these two insect pathogens can be used effectively in Illinois agriculture, additional laboratory and field studies are needed. Both enhancement of the naturally occurring alfalfa weevil fungus, or introduction of a more suitable strain of the potato leafhopper fungus, will require a thorough understanding of the factors that influence the growth and spread of disease in populations of these alfalfa pests.

Analysis of Fish Communities in Illinois Impoundments

Fishing is one of the most popular pastimes in the state. Annual license revenues from Illinois residents have exceeded 4.5 million dollars since 1980. Angling pressure has increased at a faster rate than the construction of new impoundments, and has affected fish populations significantly compared with natural causes.

Typical Illinois impoundments are very productive, so management is not necessarily the stocking of new fish, but influencing the natural productive processes to provide the size and species of fish desired by the angling public. Stocking of fish is usually expensive, but can sometimes be justified in particular cases, such as (1) when an impoundment has to be renovated, (2) for desired species outside their natural range when they cannot survive throughout the year (e.g., trout), or (3) for species which cannot reproduce or recruit successfully in the artificial environment of an impoundment (e.g., channel catfish).

There are two extreme approaches to management. The first is to act on a hunch or some unquantified previous experience. The second is to follow a prediction based on a model of the system which is in turn based on quantified previous experience. In practice, recreational fisheries management operates somewhere between these extremes, but typically close to the first. Once the experience has been gained, a good manager can succeed in this manner, but the experience cannot easily benefit a new manager, or other managers working with

similar fish communities in other impoundments, or policy makers who need to allocate resources statewide. Also, since the previous information often was not quantified or recorded, the ability to detect and correct an adverse change in the fish populations and evaluate the results of management was impaired.

To approach the second more scientific extreme requires an investment in (1) organizing a system of standardized sampling to facilitate comparisons, (2) calibrating the sampling methods under various conditions to provide unbiased measures of the fish populations, and (3) data management systems to assist managers and permit assembly of statewide data for predictive model construction and provide data for statewide resource allocation. The benefits will be both in short-term management strategies at the local and state levels, and in our scientific understanding of fish communities in impoundments, which through predictive models can assist in long-term management and future short-term decisions.

In summary, we need to increase benefits in terms of angler satisfaction by making the management process closer to biological and fiscal reality. Human resources are required which have recreational, research, and direct field sampling perspectives. Such resources are available at the Illinois Department of Conservation (DOC) and the Illinois Natural History Survey.

A project was designed and initiated by Peter Bayley in January 1984 to: (1) make the individual data sets comparable without losing the unique characteristics of each water body; (2) calibrate the standardized sampling techniques so that we can produce estimates of abundance, biomass, and biological production of fish, which are prerequisites for realistic predictive models; (3) ultimately be able to relate all the data sets for across the State with other influencing factors, such as fishing pressure, natural effects, and anticipated demands on the resource; and (4) develop a system to periodically summarize the findings so that optimal management decisions can be made.

Existing fish sampling facilities and personnel at both the DOC and the Survey and existing computers at the Survey will be utilized. Additional microcomputers are being purchased for permanent installation with DOC District Biologists who manage impoundments, and software development is underway. The project is supported by the federally administrated Dingel-Johnson fund which depends on a tax based on fishing tackle purchases. Although the project is funded for 3 years, the system of data acquisition, storage and analysis will be permanent, and the benefits will accrue over many years.

Bacterial Populations in Two Pools of the Mississippi River

Bacterial populations associated with aquatic plants in Pools 19 (Keokuk) and 26 (Grafton) of the Mississippi River represent a significant portion of the total amount of bacteria available to consumers in the pools. Bacteria contribute to the food web by transforming dissolved organic carbon released from living plants into bacterial biomass and by aiding in the decomposition of dead plant parts.

As a part of the Long-Term Ecological Research (LTER) Large Rivers study, Michael S. Henebry and Robert W. Gorden are using direct microscopic counts to estimate the amount of bacteria in the water column, in sediments, and on the surface of plants in different habitat types in Pools 19 and 26. Water, sediment, and plant samples were collected from 37 sites along eight across-the-river transects in Pool 19 in August and October 1984. Location, water depth, sediment type, and presence or absence of rooted aquatic vegetation were used to classify sites as either

Typical vegetation bed being studied is American lotus, *Nelumbo lutrea* (Photo by Mike Henebry).

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main channel, main channel border, vegetated main channel border, or side channel habitats.

Bacterial cell sizes and numbers in Pool 19 water samples were similar to those found in other freshwater systems. Bacterial populations at vegetated main channel border sites were significantly higher than those at main channel sites. The numbers of bacteria on aquatic plants such as arrowhead (*Sagittaria*) and eelgrass (*Vallisneria*) were higher than numbers in the water column and sediments.

To compare the total bacterial biomass in vegetated areas of the pool to that in areas without plants, values from the water column, sediments, and on macrophytes were converted to number of grams of carbon per square meter and then multiplied by the habitat area to yield total biomass as kilograms of bacterial carbon. Although at low flow only 7 percent of the total water area in Pool 19 is in the vegetated main channel border habitat, that habitat supported 16 percent of the bacterial biomass.

Data suggest that organic matter, produced in the plant beds and processed by bacteria is transported into vegetationless areas via current and wave action. Although the vegetated area of Pool 19 is relatively small, the decomposing plant material and associated bacteria are important sources of carbon and energy (nutrition) for consumers, such as the abundant populations of mayflies (*Hexagenia*) and fingernail clams (*Musculium*) in adjacent main channel border areas without vegetation.

Determination of the source of nutrition for the large populations of mayflies and fingernail clams is an important step in explaining the high productivity of pooled reaches of the Mississippi River. This research will continue in the summers of 1985 and 1986.

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Aquatic Plant Research and Management

Infestations of aquatic plants in ponds, lakes, and reservoirs in Illinois have increased dramatically during the past 30 years, due largely to increased nutrient influxes and the establishment of exotic species. Concurrently, there has been an increased demand for recreational and industrial uses of our water resources; these uses may be severely restricted by dense stands of aquatic plants. Therefore, safe, effective, and affordable aquatic plant control technologies are needed.

As part of the Aquatic Macrophyte Research Program at the Illinois Natural History Survey, Pamela P. Tazik, Michael J. Wiley, and their associates are formulating an effective, ecologically safe, and comprehensive aquatic plant management program for Illinois; to do so, the basic biology and ecology of aquatic plants must be understood. As a first step, they have identified the nuisance aquatic plants in Illinois and evaluated the effectiveness of current control methods.

Although Illinois has many aquatic plants that may reach nuisance proportions, generally a few species cause most of the problems. American elodea (*Elodea canadensis*), water milfoil (*Myriophyllum* spp.), coontail (*Ceratophyllum demersum*), naiads (*Najas* spp.), and pondweeds (*Potamogeton* spp.) are the primary problem plants in Illinois, infesting waters throughout the state.

Of the three basic aquatic plant control strategies (chemical, mechanical, and biological), the most commonly used in Illinois is chemical control. Seasonal control of pondweeds and naiads can usually be obtained through herbicide application, but

Potamogeton spp., one of the commoner nuisance pondweeds found in Illinois waters (Photo by Wilmer Zehr).

coontail, American elodea, and water milfoil often are not controlled effectively by herbicide application. Herbicides are expensive and require annual (or sometimes semi-annual) application; they may also be toxic to non-target aquatic organisms with improper application.

Mechanical control, such as harvesting, shading chemicals, fertilization, and benthic barriers, are used to a limited extent in Illinois. This type of control may be appropriate for ponds and small areas of lakes and reservoirs, but it is often prohibitively expensive if used in a large-scale application. Like aquatic herbicides, mechanical control methods provide short-term or seasonal control.

Biological control is not widely used in Illinois, but it holds considerable promise for future application. With biological control, an organism is introduced that will

inhibit or control the growth of aquatic plants. Herbivorous fish, mammals, invertebrates, and microorganisms are all possible bio-control agents. Unlike the other available methods, biological control may be effective over many years. The herbivorous grass carp (*Ctenopharyngodon idella*) is the most widely used and studied bio-control agent for aquatic plants. These fish have a tremendous feeding and growth capacity, making them a potent control agent. However, those traits also make them a serious potential pest, especially if they become established in the large rivers where they could reproduce. Consequently, grass carp are illegal currently in Illinois.

Two genetic derivatives of the grass carp have been produced since the late 1970's, the hybrid carp (female grass carp x male bighead carp) and the triploid grass carp (two grass carp parents). Shortly after production of these fish began, the Illinois Natural History Survey initiated a study to determine: (1) their effectiveness in controlling aquatic plants, (2) their reproductive potential, and (3) the environmental impacts associated with their use. That study indicated that neither the hybrid nor the triploid grass carp could reproduce, but only the triploid grass carp retained the plant-eating capabilities of the grass carp. The development of these sterile herbivorous carp, particularly the triploid, has made bio-control feasible and acceptable for use in Illinois. Wiley, Tazik, and associates have recommended the legalization of the sterile, triploid grass carp and have developed a computer-implemented model to aid in stocking recommendations. When these fish are legalized, Illinois citizens will be able to stock the triploid grass carp as an ecologically sage aquatic plant management mechanism.

"People" Diseases of Trees

Some of the most destructive diseases of trees are caused by humans. In spite of the amount of money and effort used to plant and maintain their trees and shrubs, some persons are unknowingly responsible for the injury and death of their trees.

Common person-caused injuries to trees are often related to construction and the building of additions to homes. Construction damage includes (1) actual mechanical damage from heavy equipment scarring the trunk and branches and cutting off the roots, (2) causing grade changes by either removing soil or placing soil over the roots, (3) changes in the water table by ditching and draining in developing subdivisions or in homesite developments, and (4) trenching and ditching close to established trees that sever large areas of the trees' root systems.

Soil compaction from running heavy equipment over the soil, especially during wet periods of the year, is destructive to both the soil structure and to the roots of the trees. The compacted soil will remain deficient in essential oxygen for proper root respiration, and water will not penetrate a hard soil surface for several months. Grass will do poorly in compacted soil, and trees and shrubs will often die.

When the soil is compacted around established trees, a 3- to 4-inch layer of woodchip mulch placed over the root area will help the soil to restructure and become less compacted over a shorter period of time than if reseeded to bluegrass. Any type of cultivation to loosen the compacted soil around established trees will be destructive to roots that normally develop in the upper 4 to 6 inches of the soil. The more shallow roots are essential to the proper uptake of nutrients and water by most urban tree species.

Excessive pruning out of large branches of trees having roots injured during construction is not recommended. A professional arborist should be consulted before construction begins, and should be retained to help maintain the trees after construction is completed. Trees can be saved and maintained in a vigorous condition with proper and timely professional advice and care.

New Publication on Shorthead Redhorse

A multidisciplinary aquatic monitoring program has been conducted in the Kankakee River near Wilmington, in an effort to characterize the segment of river near Commonwealth Edison's intake and discharge structures for the Braidwood Sta-

tion. The study area includes a variety of habitats including Horse Creek, a small tributary. Different assemblages of fishes populated the various habitat types.

The Shorthead redhorse, *Moxostoma macrolepidotum,* is one of the important and least known river fishes and its biology is detailed in the recently published Biological Notes No. 123, "The Life History of the Shorthead Redhorse, *Moxostoma macrolepidotum* in the Kankakee River Drainage, Illinois."

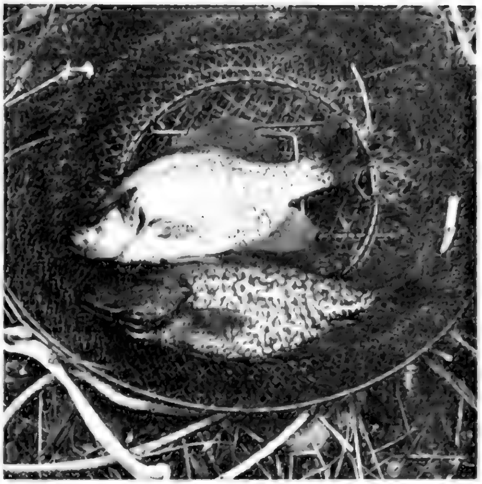
The species was studied intensively during May, August, and November of 1977, 1978, and 1979 and in August of 1981 and 1982. Supplementary collections were made during other ice-free months. The shorthead redhorse was a dominant fish in electrofishing collections. Large numbers of fish collected in August 1981 were the result of two strong year classes and high water levels that increased the susceptibility of the fish to shoreline electrofishing. Preferred habitats were cobble areas in waters 1-2 m deep with velocities of 23-63 cm/sec. Shorthead redhorse began to gather in a tributary, Horse Creek in early March and spawned in late April and early May. On April 30, 1979, 81 reproducing males and 27 females were collected in Horse Creek. Approximately 3,000 shorthead redhorse were present in a single raceway-riffle area of Horse Creek at that time. Each female produced an average of 18,000 eggs. A low recovery rate of tagged individuals indicated extensive movement and dispersion of this species from the monitoring area.

The foods eaten, types of Chironomidae (midge larvae) consumed, and a lack of burrowing mayflies in the diet suggested that shorthead redhorse fed in riffles and riffle margins.

Copies of this publication may be obtained by writing to the Chief of the Illinois Natural History Survey.

Hybrid Crappie Study

The black and white crappies are two of our most colorful and attractive fishes, and two of the most sought after by anglers. In their classic treatment of Illinois Fishes, Forbes and Richardson (1908) noted that both crappies ranged over all of Illinois,



Black and white crappie (Photo by George Bennett).

and over much of the eastern U.S. and southern Canada. The white crappie was found abundantly in "lakes, ponds, and bayous," but were plentiful also in the smaller rivers and creeks. Black crappie shared many of the same waters, but were less abundant generally than the white, showing an affinity for cooler, less turbid waters. Present distributional patterns are similar: the white is common in impoundments, both large and small; while the black has an irregular distribution in the larger reservoirs and is less common in smaller impoundments. Both may maintain relatively stable populations in large impoundments, but tend to overpopulate when stocked in small impoundments and farm ponds.

Overpopulation leads to stunting and severe competition with bass and bluegill. Many management strategies have been employed, including introduction of forage species to increase the crappie food supply, reduction of crappie numbers by various chemical or mechanical means, and use of large predators such as largemouth bass and northern pike. However, failure to develop dependable strategies for small impoundments has led managers in most of our states to forego the crappies for more manageable species. In Illinois, management recommendations now exclude crappies from farm ponds, and most biologists now favor their elimination in all impoundments smaller than 250 acres. It is

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recognized, however, that crappies are highly favored by anglers, and that a solution to the problem could increase sportfish harvests in thousands of small impoundments where crappies are now a problem, or have been excluded.

The late W. F. Childers, long-time Survey biologist, was probably the first to suggest that hybrid crappies might at least minimize the "crappie problem," and was the first to produce hybrid crappies in the laboratory and to stock them experimentally. Childers believed that natural hybrids occurred widely in Illinois, and that several 4- to 5-pound crappies examined by him were all hybrids. He believed also that hybrid crappies grow faster than either parent, and might be less inclined to overpopulate, but he never completed his investigations.

Current studies by Survey biologists Homer Buck and Mike Hooe are the first involving hybrid crappies since the pioneer work by Childers. The principal studies are being conducted in the laboratory and in earthen ponds at the Sam A. Parr Fisheries Research Center near Kinmundy. Genetic identities of experimental fish are determined by starch-gel electrophoresis in the Survey fish genetics laboratory supervised by David Philipp. The basic purpose of the investigation is to evaluate hybrid crappies as sportfish. Half-sibling hybrid and pure stock crappie fry were produced in the laboratory by stripping eggs from a female and fertilizing half with milt from a black crappie, and half with milt from a white crappie. Natural hybrids were produced also in ponds by isolating males of one species with females of the other. Both interspecific F_1 hybrids have made significantly faster first-year growths than either parent when sharing the same environments in all populations studied, and preliminary analyses indicate that second-year growths by F_1 hybrids may also be superior to that of either parent. The reciprocal F_1 hybrids were found to be indistinguishable, and to more closely resemble the black parent than the white. Morphological differences between the F_1 hybrids survived in significantly greater numbers than whites when stocked as fry, and F_1 hybrids and black crappies survived seining, netting, and handling much better than whites. All F_1 populations examined had 50:50 sex ratios, and a male F_1 hybrid backcrossed with a white female crappie. Future studies will evaluate later generations of hybrids in terms of growth, fecundity, catchability, and their ability to sustain desirable, fishable populations in small impoundments also containing desirable populations of largemouth bass and bluegills.

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Fall Food Habits of Mallards in Illinois, 1979-1982

Illinois is a major migration area for waterfowl in the Mississippi Flyway. The last comprehensive study of the food habits of waterfowl during fall migration in Illinois was conducted in 1938-1940. Since then, the wetlands and croplands of the Midwest have undergone dramatic changes.

During the hunting seasons of 1979-1982, Survey researchers Stephen P. Havera and G. Alan Perkins collected 9,300 mallard gizzards by weekly periods from 48 sites throughout Illinois. Emphasis was placed on the mallard because it comprises approximately 86 percent and 47 percent of waterfowl use in the fall in the Illinois and Mississippi river valleys, respectively, and makes up about 50 percent of the Illinois duck harvest. The mallard gizzards were examined to determine (1) the principal foods used, (2) changes in food habits since 1940, (3) variation of major food items within the state, and (4) variation of food habits within and among years.

The researchers identified a variety of food items in the gizzard contents, including 300 plant species, 65 invertebrate taxa, and one vertebrate group. Examination of food habits indicated that the Illinois River region and Mississippi River region bordering central Illinois received similar use by mallards of corn (48 percent and 49 percent by aggregate volume, respectively). Corn is generally available to mallards as waste grain in agricultural fields or on areas managed for waterfowl. The volumes of moist-soil plant seeds were also similar in gizzards collected from the Illinois River (25 percent) and the Mississippi River (20 percent). Moist-soil plants are naturally occurring annual plants that become established on exposed mud flats during the summer months.

There were some striking differences, however, in diets of mallards using the Mississippi and Illinois river valleys. Managed or cultivated agricultural foods, such as buckwheat, Japanese millet, and milo represented 10.5 percent of the diet on the Illinois River as compared with only 1.3 percent for the Mississippi. In contrast, submergent and emergent aquatic plants such as coontail and pondweeds were more prevalent in mallard gizzards from the Mississippi River (10.1 percent) than in those collected from the Illinois valley (trace). These differences can be explained by the virtual elimination of aquatic plants from the Illinois River as a result of sedi-

Mallard ducks are pictured migrating through Havana looking for food, usually the gleanings of a corn field (Photo by W. E. Clark).

mentation and its devastating effects on aquatic communities during the past three decades. The degradation of the aquatic habitat via sedimentation has not been as severe in the Mississippi River. Consequently, aquatic plants are still common among mallard diets in the Mississippi River valley, but they have been replaced in the diets of mallards frequenting the Illinois River by cultivated agricultural foods provided on private and public-managed waterfowl areas.

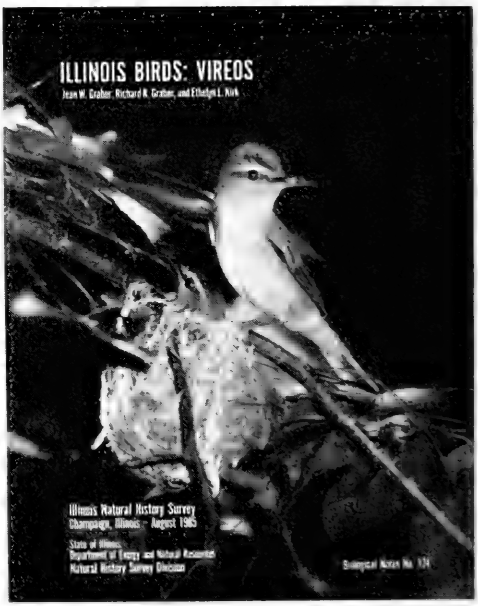
Similar results appeared when the mallard food habits from the Illinois River valley were compared between 1938-1939 and 1979-1982. During both periods, corn was the leading food item (48 percent during both periods) followed by moist-soil plants (24 percent versus 25 percent, respectively). However, the managed agricultural foods of Japanese millet, buckwheat, and milo did not occur in the mallard diets of 1938-1940, whereas aquatic plants represented 15 percent of the diet. In 1979-1982, managed agricultural foods represented 10.5 percent of the diet of mallards, but aquatic plants were essentially non-existent. Migrant mallard populations using the Illinois valley are now heavily dependent upon waste grain and managed foods while increasing their body reserves before resuming their southward trek toward wintering areas.

Analyses of mallard diets also uncovered another interesting finding. Generally the amount of corn in the diet increased during the fall in most regions of Illinois. For example, the percentage of corn in the diet increased from an average of about 35 percent in late October in the Illinois valley to about 65 percent by early December. Corn contains a high percentage of carbohydrates and, therefore, is relatively high in energy content, but many natural foods provide similar caloric values. However, a large amount of corn can usually be eaten quickly and satisfy mallards' energy requirements in a short period of time. The late season switch to corn did not occur in the diet of mallards using the confluence region of the Illinois and Mississippi rivers. In the confluence region, seeds of moist-soil plants made up approximately 50 percent of the diet throughout the fall, whereas corn consisted of only about 10 percent. Apparently natural vegetation was so abundant in this region that mallards did not utilize corn to the same degree as in other areas of Illinois. This finding might provide some insight into the diet of mallards in mid-latitude migration areas before corn was cultivated in presettlement times. Perhaps corn is replacing acorns and other mast that is no longer available to mallards as it once was in the vast expanse of timber that graced the bottomlands.

Tenth Bird Publication Available

"Illinois Birds: Vireos," Biological Notes No. 124 published in August, is the most recent publication of the Illinois Natural History Survey. This paper is the tenth in a series on Illinois birds written by Jean W. Graber, Richard R. Graber, and Ethelyn L. Kirk. In some other reports in the series, Richard R. Graber was the senior author.

According to the authors, seven species of the Vireo family occur in Illinois, one — the Philadelphia — only as a transient in spring and fall. Another species — the solitary vireo — has been found nesting only at Sand Ridge State Forest and occurs



Tenth bird publication in a series by the Grabers and Ethelyn L. Kirk.

in the state primarily as a transient. The other five species nest regularly in Illinois and occur also as migrants. They are the white-eyed vireo, Bell's vireo, yellow-throated vireo, the warbling vireo, and the red-eyed vireo.

As in the earlier bird Biological Notes, the emphasis is on population dynamics and habitat relationships, not their taxonomy. Where no authority is cited for a record, the record is the Grabers'. Sexual dimorphism in plumage is essentiallly lacking in vireos, and reference to sex in the field observations are based on behavior, especially singing.

The paper discusses not only the distribution of the various species in Illinois, but also maps their general distribution in the United States. Other data include information about egg laying and migration seasons, nesting habits, food preferences, and phonetic interpretations of the birds' song. The excellent photography was done chiefly by the authors and shows close-ups of most of the birds on their nests.

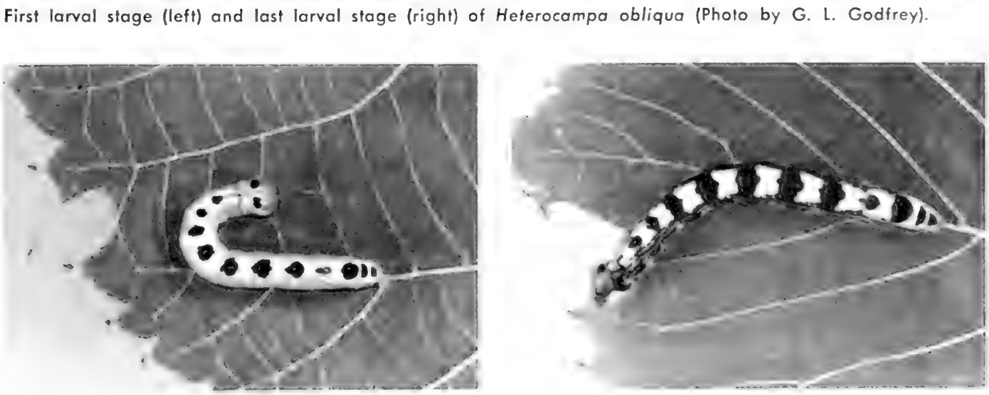
Books included in the series are Biological Notes No. 68, 1970, "Illinois Birds: Mimidae"; Biological Notes No. 75, 1971, "Illinois Birds: Turidae": Biological Notes No. 80, 1972, "Illinois Birds: Hirundinidae"; Biological Notes No. 83, 1973, "Illinois Birds: Laniidae"; Biological Notes No. 86, 1974, "Illinois Birds: Tyrannidae"; Biological Notes No. 102, 1977, "Illinois Birds: Picidae"; Biological Notes No. 109, 1978, "Illinois Birds: Ciconiiformes"; Biological Notes No. 110, 1979, "Illinois Birds: Syviidae"; and Biological Notes No. 118, 1983, "Illinois Birds: Wood Warblers."

These publications are available upon request to Chief Paul Risser, Illinois Natural History Survey, 607 East Peabody Drive, Champaign, Illinois 61820.

Forest Caterpillars

Notodontid caterpillars feed almost exclusively on the foliage of broad-leafed shrubs and trees in natural and maintained settings. Several species, including the variable oakleaf caterpillar (*Lochmaeus manteo*), redhumped oak worm (*Symmerista albifrons*), walnut caterpillar (*Datana in-*

First larval stage (left) and last larval stage (right) of *Heterocampa obliqua* (Photo by G. L. Godfrey).



Last larval stage of *Ellida caniplaga* following moult (left) and 32 hours later (right) (Photos by G. L. Godfrey).

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tegerrima), and saddled prominent caterpillar (*Heterocampa guttivitta*) are notable defoliators. As leaf eaters, notodontids are well adapted to an arboreal habitat and have some very interesting ways of avoiding would-be predators and parasitoids. These include chemical (some species are capable of spraying formic acid), physical (synchronized head and tail jerking by gregarious species), and cryptic (resemblance of whole, partly eaten, twisted, or tattered leaves) defenses.

During the course of larval development, i.e., the growing and moulting process, some notodontids exhibit remarkable changes in body shape and/or coloration. Two examples of this are illustrated by *Heterocampa obliqua* which feeds on various species of oak, especially white oak and burr oak, and *Ellida caniplaga* which occurs on basswood.

The first larval stage of *Heterocampa obliqua* is adorned with branched, antler-like tubercles and is nearly solidly colored. The "antlers" disappear after the first moult, and the subsequent larval stages are evenly contoured and distinctly patterned. There virtually are no clues to indicate that the latter larval stages represent the same species as does the first stage. *Ellida caniplaga* maintains the same basic body shape during successive larval stages but undergoes a distinct intensification of coloration during the first 24-32 hours after moulting into the last stage.

There is a basic change in the feeding behavior associated with larval development. Entomologists have long known that an early stage notodontid caterpillar skeletonizes the leaf on which it feeds (it eats into the flat surface of the leaf blade, removing soft tissues and leaving the veinlets and veins), but that an older caterpillar moves to the leaf's edge where it removes strips of tissue. Survey entomologist, George L. Godfrey, is showing that this switch is correlated with a change in the adaptive design of the mandible. The mandibles of the more advanced stages are smooth and are used for clipping. The loss of teeth is not attributable to wear.

The basic purpose of Godfrey's study of the developmental morphology and the feeding behavior of notodontid caterpillars is an attempt to understand more clearly the phylogenetic relationships among the notodontid species and between them and the related noctuids (armyworms, cutworms, and green fruitworms). This work is being done in collaboration with fellow Survey entomologist, James E. Appleby, to enhance the recognition of all larval stages for selected notodontid species during the development of management programs for Illinois forest insect pests.

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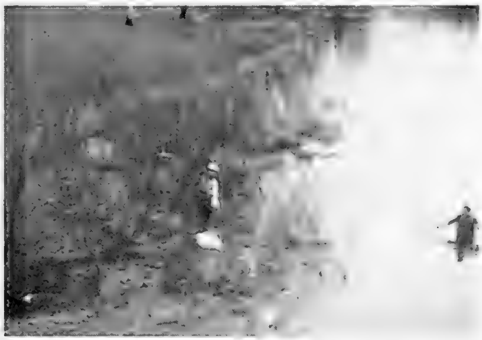
Des Plaines River Microorganisms

Since the passage and enforcement of laws regulating point sources of pollution (e.g., power plant effluents and discharges from sewage treatment plants), contamination of many rivers and streams in Illinois has been reduced. However, because of numerous nonpoint sources of pollution (e.g., topsoil runoff from agriculture and road construction), habitats for plants and animals have not been restored and the variety of native species found in our waterways has decreased. The Des Plaines River and its natural floodplain in the Lake County Forest Preserve in northern Illinois provide good examples of relatively "clean" habitats that are degraded because of stream channelization and excessive siltation.

In spring 1985, the Des Plaines River Wetlands Demonstration Project was initiated by Dr. Donald Hey of Wetlands Research, Inc., to determine if the diversity of plants and animals could be enhanced by re-creating a wet prairie habitat along the river, reducing the river's silt load, and increasing the diversity of aquatic and terrestrial habitats. The Des Plaines River will be diverted through a series of restored marshy wetlands, which should remove much of the silt load. The clarified water from the experimental wetlands will then flow through two quarry lakes to increase their nutrient supply, and ultimately increase fish production.



Two researchers gather samples from the Des Plaines River (Photo by Virginia Henebry).

As part of a multi-disciplinary team, Michael Henebry and Robert Gordon, Aquatic Biology Section, collected baseline data on the microbial populations (algae, bacteria, and Protozoa) in the Des Plaines River, its associated wetlands, and the quarry lakes, to help determine if the site is now receiving sewage or other forms of organic pollution.

Bacterial types, numbers, and biomass in water column samples were comparable to those found in silt-laden, but otherwise unpolluted, sites. The variety and total numbers of Protozoa, which feed on bacteria, were also low. The number of algal species and the population abundance of algae in the river and quarry lakes were well within the range expected for heavily silted rivers or unproductive lakes. Algal populations at the river sites were probably limited by light penetration through high levels of suspended solids. In quarry lakes, where water turbidity was low, algal abundance was significantly higher but was still limited by low nutrient levels. The production of algae in both the river and quarry lakes was too low to provide an adequate base for abundant higher organisms, such as fish.

In summary, there was no microbiological evidence of significant amounts of sewage pollution or organic enrichment at the project site. On the basis of indicator bacteria and total microbial populations, both the Des Plaines River and the quarry lakes were relatively unpolluted and unproductive.

The abundance and variety of bacteria, algae, and Protozoa is expected to increase in the proposed experimental wetland areas because of increased retention of nutrients and improved water clarity. The wetland plants will also act as attachment sites for microorganisms; this additional periphyton colonization and primary production should result in the production of important fish species.

Catalogs, Life Histories, and Bibliographies

In a dedicated effort to enable the citizens of Illinois to make the best possible use of its natural resources, the Illinois Natural History Survey conducts a wide variety of research projects related to the biological populations and ecosystems of the state. Much of this research is of a rather specialized nature and deals with sophisticated laboratory equipment, exotic field measuring devices, or complex theoretical and analytical techniques. Examples might include the tracking of migrating insects with radar or computer simulation models connecting fish behavior with telemetry data on dissolved oxygen levels in streams.

However, one of the unique features of the Survey is its long-term run of biological and ecological processes. This has resulted in many publications which are definitive benchmarks on the plants and animals of the state and future evaluations of the natural resources will be based on these fundamental life-history studies.

Since the early years of its 127-year existence, the Survey has made extensive studies of the Illinois flora and fauna which are probably better known than in any other state. Much of the resulting knowledge has been offered in life-history studies, catalogs, and bibliographies which conveniently organize information about species and habitats.

CATALOGS AND LIFE HISTORY STUDIES — VERTEBRATES

Amphibians and reptiles (Smith 1961)

Birds (Ridgeway 1881, 1889, 1895)
- Ciconiiformes (Graber, Graber, and Kirk 1978)
- Ducks, geese, and swans (Bellrose 1976)
- Geese (Hanson and Jones 1976)
- Hirundinidae (Graber, Graber, and Kirk 1972)
- Laniidae (Graber, Graber, and Kirk 1973)
- Mimidae (Graber, Graber, and Kirk 1970)
- Mourning dove (Hanson and Kossack 1963)
- Picidae (Graber, Graber, and Kirk 1977)
- Pheasants (Labisky 1975), (Warner 1981)
- Prairie-chicken (Yeatter 1943), (Westemeier 1980)
- Prothonotary warbler (Loucks 1894)
- Sylviidae (Graber, Graber, and Kirk 1979)
- Tyrannidae (Graber, Graber, and Kirk 1974)
- Turdidae (Graber, Graber, and Kirk 1971)
- Vireos (Graber, Graber, and Kirk 1985)
- Wood warbler (Graber, Graber, and Kirk 1983)

Cottontail rabbit (Lord 1963)

Fish
- Bantam sunfish (Burr 1977)
- Blackside darter (Thomas 1970)
- Cavefish (Smith and Welch 1978)
- Cypress darter (Burr and Page 1978)
- Darters (Page 1983)
- Dusky darter (Page and Smith 1970)
- Fishes (Jordan 1878), (Forbes and Richardson 1920), (O'Donnell 1935), and (Smith 1979)
- Knothead carp (Thompson 1928)
- Least darter (Burr and Page 1979)
- Logsperch (Thomas 1970)
- Mud darter (Cummings, Grady, and Burr 1984)
- River darter (Thomas 1970)
- Shorthead redhorse (Sule and Skelly 1984)
- Slabrock darter (Page and Burr 1976)

Some publications of Survey scientists (Photo by Les Woodrum).

Slenderhead darter (Thomas 1970), (Page and Smith 1971)
Slough darter (Braasch and Smith 1967)
Spottail darter (Page 1974)
Stripetail darter (Page 1975)
Warmouth (Larimore 1957)
White crappie (Hansen 1951)

Fox and gray squirrels (Brown and Yeager 1945)

Mammals (Hoffmeister and Mohr 1957)

Reptiles and amphibians (Garman 1892)

White-tailed deer (Pietsch 1954)

CATALOGS AND LIFE HISTORY STUDIES — INVERTEBRATES

Agromzidae (Mulloch 1921)
Ants (Ross, Rotramel, and LaBerge 1971)
Bees (Schrader and LaBerge 1978)
Butterflies (Irwin and Downey 1973)
Caddisflies (Ross 1944)
Crayfishes and shrimps (Page 1985)
Damsel flies (Garman 1917)
Dermoptera and Orthoptera (Hebard 1934)
Dragonflies (Needham and Hart 1901)
Hirudinea (Moore 1901)
Jassidae (Woodworth 1887)
Land snail (Baker 1939)
Leafhoppers (DeLong 1948)
Mosquitos (Ross 1947)
Mayflies (Burks 1953)
Molluscs (Baker 1906)
Oribatoidea (Ewing 1909)
Orthoptera (Thomas 1876
Pentatomoidea (Hart 1919)
Plant bugs (Knight 1941)
Plant lice (Hottes and Frison 1931)
Pseudoscorpions (Hoff 1949)
Scorpionflies (Webb, Penny, and Marlin 1975)
Soybean insects (Kogan and Kuhlman 1982)
Soybean spiders (LeSar and Unzicker 1978)
Stoneflies (Frison 1935)
True flies (Pechuman, Webb, and Tesky 1983)
Treehoppers (Goding 1894)
Terevidae (Irwin and Lyneborg 1980)
Thrips (Stannard 1968)

LIFE HISTORY STUDIES — PLANTS AND VEGETATION

Plants
Drug plants (Tehon 1951)
Filmy fern (Evers 1961)
Fungi (Burrill 1876, 1885)
Mosses, liverworts, and lichens (Wolf and Hall 1878)
Native and naturalized trees (Miller and Tehon 1929)
Native shrubs (Tehon 1942)
Plankton (Kofoid 1897, 1898, 1899, 1903, and 1908)
Trees (Carter 1955, 1966)
Wildflowers (Survey 1936)

Vegetation
Forest survey (Miller 1923), (Chapman and Miller 1924), (Telford 1926)
Hill prairies (Evers 1955)
Prairie (Sampson 1921)
Sand areas (Hart and Gleason 1907)

BIBLIOGRAPHIES — INVERTEBRATES

Alfalfa weevil (Wood, Armbrust, Bartell, and Irwin 1978)
Bean leaf beetles (Nichols, Kogan, and Waldbauer 1974)
Bollworm, earworm, and fruitworm and budworm (Kogan, Sell, Stinner, Bradley and Kogan 1978)
Crucifer weevil (Bouseman, Irwin, and Eastman 1978)

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Egyptian alfalfa weevil (Wood, Armbrust, Bartell, and Irwin 1978)

Green stink bug (DeWitt and Godfrey 1972)

Mexican bean beetles (Nichols and Kogan 1972)

Northern and western corn rootworm (Irwin 1977)

Northern and western corn rootworm (Luckmann, Chiang, Ortman, and Nichols 1974)

Pea aphid (Harper, Miska, Manglitz, Irwin, and Armbrust 1978)

Pinewood nematode (Kogan, Appleby, and Bouseman 1982)

Pod borers (Qu and Kogan 1984)

Potato leafhopper (Gyrisco, Landman, York, Irwin, and Armbrust 1978)

Spotted alfalfa weevil (Davis, Nichols, and Armbrust 1974)

Velvetbean caterpillar (Ford, Strayer, Reid, and Godfrey 1975)

Weevil species (Morrison, Pass, Nichols, and Armbrust 1974)

BIBLIOGRAPHIES — VERTEBRATES

Fur animals (Yeager 1941)

Herpetological literature (Morris, Funk, and Smith 1983)

BIBLIOGRAPHIES — PLANTS AND VEGETATION

Bryophytes (McKnight 1986)

Vegetation (Risser 1984)

Recent Survey Publications

Godfrey, George, Chairman; John Bouseman, William Edwards, Kenneth Robertson, and Robert Zewadski, Eds. 125 years of biological research 1858-1983: A symposium. Proceedings of the 125th Anniversary Symposium of the Illinois Natural History Survey. Bulletin 33, Article 3, August 1985. p. 139-334.

Graber, Richard R., Jean W. Graber, and Ethelyn L. Kirk. 1985. Illinois birds: Vireos. Illinois Natural History Survey Biological Notes No. 124. 38 p.

Page, Lawrence M. 1985. The crayfishes and shrimps (Decapoda) of Illinois. Illinois Natural History Survey Bulletin, Vol. 33, Art. 4. p. 335-448.

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NOVEMBER [illegible]

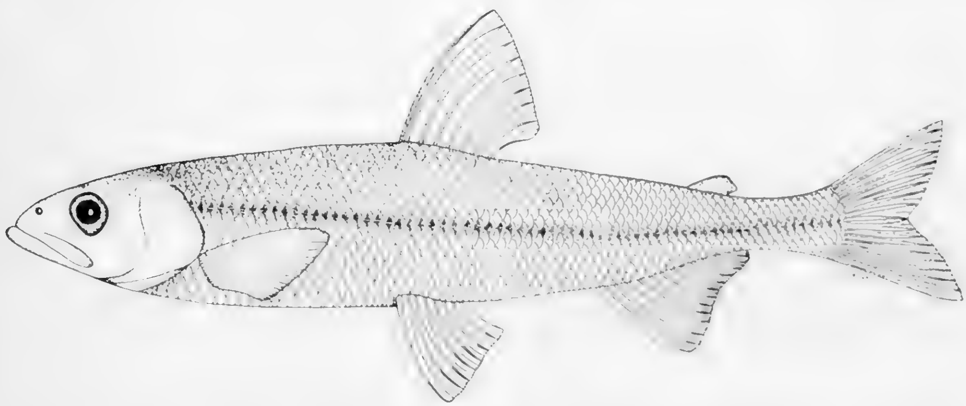
Smelt Fishing in Lake Michigan

Rainbow smelt (*Osmerus mordax*) support a lively, if brief, sport fishery along the Illinois shoreline each spring. On almost any Saturday evening in April, over 1,000 smelt fishermen may crowd Montrose Harbor and the immediate vicinity, while another 5,000 may use other sites along the shoreline of Lake and Cook counties. Most fishermen use gill nets — curtains of netting designed to entangle the gill covers of the small silvery fish as they swim along the shore seeking places to spawn.

Smelt are anadromous. The adults of ocean-dwelling populations migrate for spawning into freshwater tributaries along northern coastlines of North America, Europe, and Asia. In Lake Michigan, smelt are vulnerable to shore fishermen in spring as they swim into the tributary streams or shallow areas to spawn. In Illinois, where tributary streams are largely nonexistent and sheltered shallows are rare, the fate of eggs is unknown. In other states bordering Lake Michigan, mature smelt go upstream at night, deposit their eggs, and retreat downstream the following morning. Fertile eggs hatch in 10-30 days and the fry drift downstream into the lake.

During the spawning peak, anglers may catch hundreds of fish each night, averaging over 50 smelt per net per hour. One party of five fishermen this spring landed over 1,000 smelt in approximately 2 hours on a Sunday night. However, the catch is unpredictable; the following Saturday, the catch rate was less than one fish per net per hour for all fishermen interviewed.

During the spawning run of 1985, William H. Horns and his assistants in the Aquatic Biology Section, with support from the Illinois Department of Conservation, conducted a creel of the smelt fishery. Fishing activity was assessed on 10 nights and 749 smelt fishermen were interviewed to determine the economic importance of the fishery. Each fisherman was asked how much he or she spent on food, gear, and



The rainbow smelt is usually a green-gray color with a silvery bottom (Original drawing by Craig Ronto).

transportation for the present trip. The average reported expenditure was $6.00. It was estimated from the nightly head counts that Illinois residents made 70,000 trips to Lake Michigan to fish for smelt, for an estimated total seasonal expenditure of $420,000.

Smelt were introduced inadvertently into Lake Michigan sometime between 1912 and 1923 and the population has fluctuated widely since then. The seed stock for Lake Michigan smelt probably was derived from the freshwater population native to Green Lake, Maine. The smelt that colonized Lake Michigan migrated from Crystal Lake, Michigan, where smelt were stocked in 1912 as forage for the introduced Atlantic salmon. The first smelt found in Lake Michigan was captured in 1923. By 1936, smelt could be found throughout the lake. The commercial harvest of smelt has varied widely in Lake Michigan, reaching a peak of 9.1 million pounds in 1958. In Illinois today the harvest of smelt by commercial fishermen is negligible.

Smelt have often been blamed for the decline of lake herring in Lake Michigan. Although smelt will eat lake herring fry and the life histories and spatial distributions of the two species would permit predation, the evidence against smelt is only circumstantial and may be confused by other factors, such as human exploitation and rapid expansion of alewife populations several years ago. Dramatic fluctuations of other Lake Michigan fish populations including sea lampreys, lake trout, yellow perch, and emerald shiners, have also occurred in this century.

Smelt may be assuming a position of greater importance in the diet of salmonids in southern Lake Michigan. For many years, alewives have comprised the bulk of the diets of chinook salmon, coho salmon, and lake trout. However, with the recent declines in alewife populations, smelt are being consumed at higher rates and may become an important food for salmon and trout populations in Lake Michigan.

Scanning electron microscope photo of hyphae of a canker fungus in xylem vessels of healthy white birch, showing a hole in the cell wall of a burst hyphal tip (Photo by J. M. McPartland).

Enzymes Versus Fungi?

Fungi that cause plant diseases commonly enter resistant and susceptible host plants with equal frequency, but are unable to attack and damage resistant hosts. However, even resistant plants may become susceptible to fungal attack if they are weakened by environmental stresses. Many of the stem cankers and root rots of trees and shrubs appear following drought periods or after plants are subjected to freezing stresses during the winter.

The mechanisms involved in disaster resistance have been studied intensively over many years, yet we understand little about how these mechanisms operate. In most cases, resistance is an active metabolic response of the plant to infection. Some plants produce compounds called phytoalexins, which inhibit fungal growth, while others produce enzymes or toxic compounds that kill fungi. Nearly all of our knowledge on disease resistance mechanisms comes from research on crop plants. How trees and shrubs resist attack by pathogens has not received much attention by researchers.

In a recent study on the influence of environmental stresses on stem canker diseases of woody plants, Survey plant pathologists D. F. Schoeneweiss and J. M. McPartland used a scanning electron microscope (SEM) to examine the morphology of canker fungi in healthy and drought-stressed stems of white birch. At this ex-

Orconectes stannardi, one of the two species of crayfish endemic to Illinois, occurs only in the Little Wabash River system (Photo by Lawrence Page).

tremely high magnification, the SEM revealed interesting surface structures of fungal hyphae. A high percentage of the hyphal tips, which are the growing points of fungal hyphae, were swollen and burst in healthy stem tissue, while those in stressed stems appeared normal. A closer examination revealed distinct holes in the cell walls of burst hyphal tips, indicating possible enzyme degradation of the cell walls.

Enzymes that lyse or degrade cell walls of fungi are known to be present in forest trees and it has been hypothesized that these enzymes serve a disease-resistant mechanism against fungal attack. Results of research at the Survey support this hypothesis. When and how these enzymes are produced and the effect of environmental stresses on these processes are questions that will require additional research to answer.

The Crayfishes and Shrimps (Decapoda) of Illinois

The first article in the first volume of the *Bulletin* of the Illinois Museum of Natural History (which later became the Illinois Natural History Survey) was an annotated list of the Crustacea of Illinois. It was written by Stephen A. Forbes, the first Chief of the Survey, and noted the presence in Illinois of nine species of decapods (crayfishes and shrimps). Little research on the systematics and distribution of these organisms was published subsequently to that early report, although two unpublished theses on the ecology and distribution of crayfishes were completed at the University of Illinois (in 1912 and 1955).

The recently published "The Crayfishes and Shrimps (Decapods) of Illinois" (Illinois Natural History Survey *Bulletin* 33 (4):335-448) was based on collections made at 1,294 localities in Illinois between 1972 and 1982, and raises to 23 the number of decapod species known in the state. Although Illinois decapods constitute a group of only 23 species, they often are present in large populations, are among our largest aquatic invertebrates, and exert an important influence on the ecology of Illinois streams and lakes.

The greatest diversity of crayfishes and shrimps in Illinois occurs in the extreme southern part of the state. Seventeen of the 23 species in Illinois can be found in the Shawnee Hills and on the Coastal Plain; 10 species are restricted to this area. Two crayfishes, *Orconectes illinoiensis* and *O. stannardi,* occur only in Illinois.

Two species known historically in Illinois appear now to be extirpated. One of them, the crayfish *Cambarus robustus,* may have disappeared naturally rather than because of man-induced changes in the environment. Our earliest records indicate that *C. robustuswar* is relict in Illinois, presumably having been reduced from a more widespread distribution to small areas near Quincy (found in 1885) and Decatur (1912). Elsewhere in the U.S. and Canada, it inhabits cool to cold streams. It apparently was reduced in warm postglacial Illinois to small populations that subsequently were unable to perpetuate themselves. The other species, the shrimp *Macrobrachium ohione,* probably disappeared because of the extensive modification and degradation of Illinois' largest rivers. Four other species appear now to be in grave

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danger of extirpation and have been recommended for inclusion on Illinois' List of Endangered and Threatened Species.

The most recent addition to the Illinois fauna is a crayfish (*Orconectes rusticus*) native to southern Ohio and northern Kentucky but now distributed widely outside its native range through its extensive use as fish bait. It has become established in several streams in northeastern Illinois and near Peoria. Once introduced, this species usually displaces native species and expands its range, apparently because it is a large and aggressive species able to survive in disturbed habitats. Because it displaces native species and is a vigorous consumer of aquatic vegetation, its continued use as bait in Illinois should be discouraged.

"The Crayfishes and Shrimps (Decapoda) of Illinois," by Survey zoologist L. M. Page, describes the appearance of each species, discusses its distribution, both within and outside Illinois, describes characteristics of its habitat, its diet and its reproductive cycle. This publication, which may be obtained by writing to the Chief, INHS, is the latest in the Survey's series of reports on the biota of Illinois.

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NATURAL HISTORY SURVEY REPORTS

DECEMBER 1985, NO. 25[illegible]

A Directory of Systematists and Ecologists in Illinois

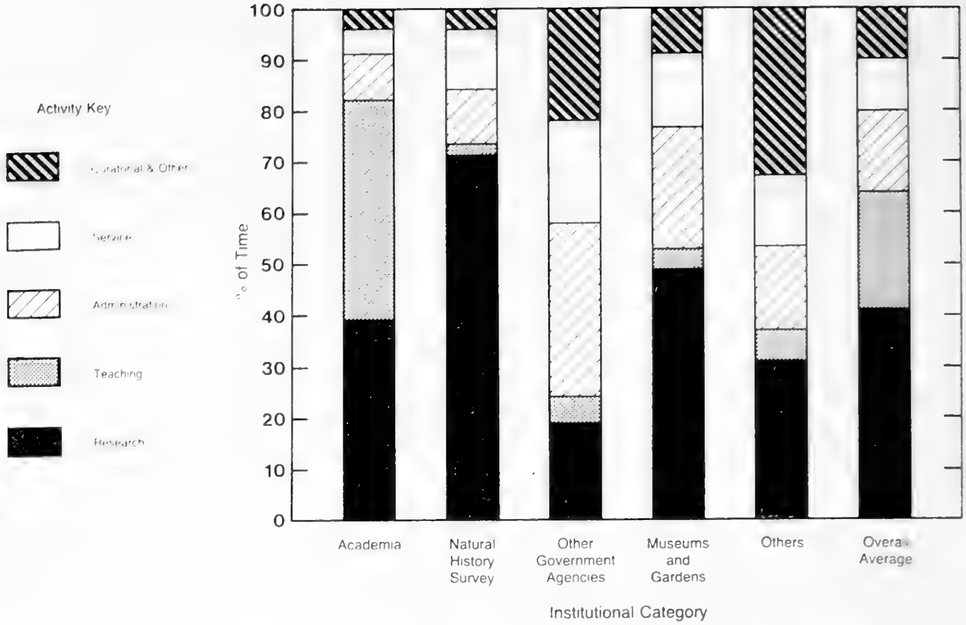
A data base of systematists and ecologists that live and/or work in Illinois has been compiled by scientists of the Illinois Natural History Survey. *A Directory of Illinois Systematists and Ecologists* will be published early in 1986 with partial financial support from the Illinois Department of Transportation, Bureau of Location and Environment. The ongoing project is under the direction of Kenneth R. Robertson, with Philip J. Burton and Bill N. McKnight (all of the Survey's Section of Botany and Plant Pathology) doing the data computerization and summarization.

Illinois is fortunate in having a large number of biological systematists and ecologists affiliated with colleges, universities, museums, botanical and zoological gardens, private companies, and governmental agencies. While a number of professional societies have membership lists, there has been no single source that gives addresses, telephone numbers, and areas of expertise for this group of scientists in Illinois.

Systematists study the classification and evolutionary relationships of organisms, while ecologists study the interactions of organisms with their biotic and abiotic environments. Systematists and ecologists generally share common interests in the evolutionary history and dynamics of organisms and in the conservation of their existing populations. In addition, both groups of scientists include field biologists well versed in the taxonomic identification of organisms and the estimation of population sizes and habitat requirements. Because of increased environmental awareness, the practical skills of this group of researchers are in high demand for use in environmental impact statements, natural area inventory and management, agricultural and forestry management, and for public education.

Information for the directory was obtained from a questionnaire that was mailed to more than 800 persons in January 1984. All responses (435) received by December 1984 have been entered into computer files. The directory includes a summary of responses to all questions and is organized alphabetically by name. Separate indices have been prepared for broad groups of organisms studied, systematic techniques used, and ecological interests, as well as for specific geographical place-names and key words denoting areas of taxonomic and ecological expertise. The indexing system allows complete cross tabulation of chosen response categories and/or key words. Both the data base and the published directory will be updated periodically to keep them current. Working scientists should find the directory handy as an address book of colleagues, and others are expected to use it as a resource book to locate systematists and ecologists with specific areas of expertise.

Many interesting features of this segment of the biological research community became apparent while summarizing the information supplied by respondents. For example, almost all respondents (96.5%) listed Illinois as their address: within the state, Urbana-Champaign (with 111 respondents) and Chicago (79 respondents) have the largest number of respondents. Half of the respondents (49.1%) are affiliated with colleges and universities, while



A Directory of Illinois Systematists and Ecologists includes summaries of the time commitments (shown here by affiliation) and research interests of this group of scientists in Illinois (graph drawn by Phil Burton and Bill McKnight).

the remainder are approximately evenly distributed among the Illinois Natural History Survey (14.2%), other state, federal and municipal agencies (14.0%), museums, arboreta, parks, gardens, and zoos (11.6%), and others (11.1%).

Differences in time-allocation among respondents were some of the most interesting results summarized from the biographical data presented here in a graph by two of the authors (see above).

A total of 386 respondents (89.8%) reported having a bachelor's degree, 323 (75.1%) have or are working on a master's degree, and 290 respondents (67.4%) have or are working on a doctoral degree. These figures are indicative of the long period of training and post-graduate work generally required to be a practicing systematist or ecologist. Of the 1,013 college degrees reported by respondents, a total of 345 (34.1%) were awarded by Illinois colleges or universities. The average year for a bachelor's degree was 1965, 1969 for a master's degree, and 1971 for a doctorate. On the average, respondents have been with their organizations since 1973, indicating an experienced contingent of resident biologists.

All individuals included in the directory will receive a copy, while other interested persons may obtain single copies of this *Special Publication 3* free of charge from the Office of the Chief, Illinois Natural History Survey (address at the end of this publication).

Sediment Contamination in Waukegan Harbor

Waukegan, situated in northeastern Illinois 36 miles north of Chicago and 8 miles south of the Wisconsin border, is one of the state's primary Lake Michigan ports. Waukegan Harbor handles commercial shipping, serves as a base for chartered fishing boat excursions, and is a major center for pleasure craft. Since 1975 the harbor has been identified as a site of serious contamination by polychlorinated biphenyls (PCB's).

PCB's are a family of synthetic organic compounds with high heat capacity, low electrical conductivity, and strong resistance to oxidation and vaporization. They were used as insulating material for electrical transformers and capacitors, and as a heat-absorbing medium in the cooling phase of

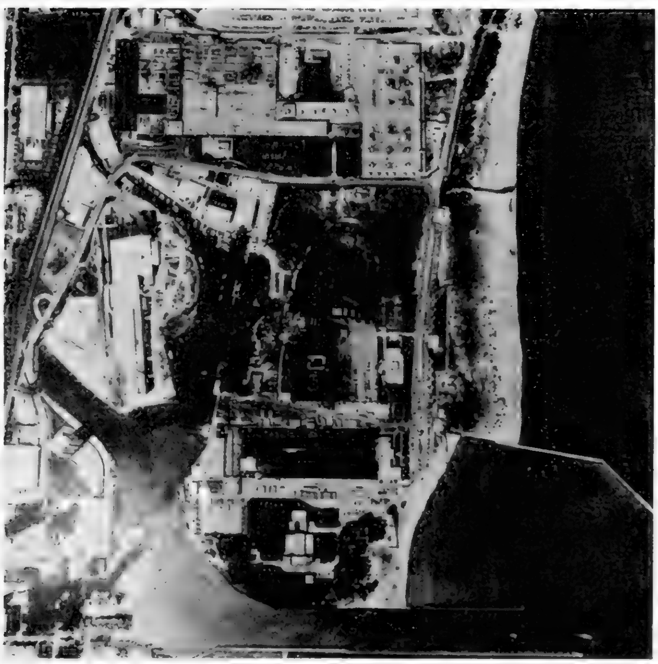
metal casting processes. PCB's are very stable molecules, tending to persist for many years if released into the environment. While not very soluble in water, they are highly soluble in lipids and oils, permitting them to accumulate in fatty tissues. Tissue concentrations of PCB's are magnified as they move up the food chain, and laboratory studies have linked them to liver cancer in rats, infertility in rhesus monkeys, and stomach nodules in dogs.

In 1979 the United States Environmental Protection Agency (USEPA) expressed concern about human health risks from consuming fish caught near Waukegan. Preliminary studies showed high PCB concentration in sediments at many locations in Waukegan Harbor and in 1981 a clean-up program was proposed. Since that time a lengthy series of litigations between USEPA and Outboard Marine Corporation (OMC) has forestalled any remedial action. The situation is complicated by the fact that accumulating sediments have reduced water depths in some locations to the point where navigation is limited. The extensive dredging operations required to correct this would create further environmental problems.

A team of State Survey scientists has been formed recently to answer some questions concerning the Waukegan Harbor PCB problem. Michael Henebry and Philippe Ross, both in the Aquatic Biology Section of the Natural History Survey, and J. Bruno Risatti, in the Geochemistry Section of the State Geological Survey, have received a grant from the State Department of Energy and Natural Resources (DENR), through the Hazardous Waste Research and Information Center (HWRIC), for the "Assessment of Ecotoxicological Hazard of Waukegan Harbor Sediments."

One of their objectives is a thorough sampling and mapping of the area to determine the extent of the contamination problem. PCB concentrations in sediments, benthic organisms, and fish will be measured. These results will be especially useful because many data files from preliminary studies have been legally sequestered pending the outcome of the judicial process.

Using a process known as *elutriation,* the research team will simulate the effect of dredging operations on the release of PCB's and other contaminants from the sediments into the water column. A series of toxicological tests will help estimate risks to



An aerial view of the Waukegan harbor. Lake Michigan is to the east (photo courtesy D. Caplice, USEPA).

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aquatic life. These tests will measure mortality and growth rates for zooplankton and nematodes, sublethal effects on metabolic processes of bacteria and algae, and mutagenesis in bacteria.

Another series of tests will look at the effects of exposure to Waukegan Harbor water on aquatic protozoan communities. Artificial substrates made of polyurethane foam blocks will be used to collect protozoans at a relatively "clean" site in Lake Michigan. Some of these colonized substrates will then be transferred to sites in the harbor, and the number of different species and their population densities will be measured over different time intervals and compared with substrates remaining at the clean site.

Recent work on PCB's in sediments suggests that anaerobic bacteria may declorinate PCB's and utilize these compounds as a source of materials for growth. This process, which could help alleviate the contamination problem in Waukegan Harbor, is being studied in two ways. First, intact sediment cores are taken back to the laboratory where PCB breakdown rates from specific sites are determined by analyzing PCB concentrations in sediments that have been incubated at different temperatures for various periods of time. Overall bacterial activity in the sediments containing PCB's will be correlated with methane production. In this way the possibilities for natural breakdown can be estimated. Second, the feasibility of introducing other bacterial species to accelerate the breakdown process will be assessed. If sediments in Waukegan Harbor and other contaminated sites could be "seeded" with PCB-degrading organisms (which would then die off when no more PCB's remained), this would be an exciting development in environmental waste management.

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